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CONWAY MACMILLAN, *State Botanist*

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GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.
CONWAY MACMILLAN, *State Botanist*

Minnesota Botanical Studies

Contents

Third Series

Part I - - March 31, 1903

MINNEAPOLIS, MINN.
1903

I. OBSERVATIONS ON EGREGIA MENZIESII.

FRANCIS RAMALEY.

INTRODUCTION.

Egregia menziesii is one of the largest and most conspicuous of the marine plants occurring on the shores of Vancouver Island. Its great abundance makes it a favorable object of study. It is easily collected at times of extreme low water when it is found in the zone with *Alaria* and *Laminaria*. A morphological study of the plant was made in the field and in the laboratory of the Minnesota Seaside Station. This study has since been carried on with preserved material. The author desires to thank Professor Conway MacMillan for suggesting to him the subject for study and for aid during the progress of the work. He is also under obligation to Miss Josephine F. Tilden for helpful suggestions.

This plant was first described by Turner[1] as *Fucus menziesii*. It was afterwards referred to the genus *Macrocystis* by C. A. Agardh[2] and was later called *Phyllospora menziesii* by the same author.[3] In 1876 Areschoug[4] made it the type of a new genus, *Egregia*. Descriptions of the plant or records of its collection have been given in numerous works besides those mentioned above.[5]

The present writer has not had access to Turner's work but that author's description and figure are copied by later writers.

DISTRIBUTION.

The plant has been collected at various points along the northwest coast of America, first by Menzies, who obtained it as far north as Nootka Sound, later by botanists of the Beechey voyage[6] and by Dr. Lyall and C. Wood at Esquimalt and Fuca Strait.[7] In later years collections have been made by Dr. Eisen, Dr. Anderson, Dr. Howe, Professor Saunders, Dr. Setchell, Miss Tilden and others in California, Washington and British Columbia. According to Professor Setchell[8] *Egregia menziesii*

extends to Port Harford some distance south of San Francisco. Below this point it is replaced by *Egregia lævigata* Setchell with its numerous forms. The exact northern limit of distribution is not known.

External Morphology.

The young plant consists of hold-fast (root area) and frond (shoot area), the latter consisting of a short stipe and a well-developed lamina (*Plate II.*). The growing point is situated at the base of the lamina. In early life the plant has much the appearance of a young *Laminaria* or *Alaria*. The stipe soon branches in the merismatic region, each branch becoming differentiated into stipe portion (rachis) and lamina. Both rachis and lamina increase in length but the lamina commonly attains a length of only 3 to 5 dm., while the rachis may become very long. Some plants collected in the month of July were 6 to 8 meters in length. The lamina grows but very little after the rachis has attained a length of one meter.

The mature plant may have from ten to forty long branches and be of great size (*Plate I.*). The branched basal part of the frond resembles the basal part of *Lessonia*. At the sides of the rachis and lamina of each branch there are rows of closely packed leaf-like proliferations of various shapes. Plants of the related genus *Alaria* also have phylloid outgrowths but they are entirely confined to the stipe, never appearing on the lamina.

The holdfast. — In large plants this is a convex disc about 1 dm. in diameter, rather smooth on the attached surface, while the upper surface consists of dichotomously much-branched, overlapping, nearly cylindrical blunt fibers about 5 mm. in diameter, smooth and of a light brown color.

The stipe. — At the point of union with the holdfast the stipe is nearly terete but the first branches are given off within a distance of 2 or 3 cm. and from that point they are all somewhat flattened-cylindrical in shape, becoming at a little distance strap-shaped. This flattened strap shape is maintained the entire length of the rachis of each branch. Branching does not occur at any great distance from the holdfast. The rachis is dark brown in color, distinctly roughened with tuberculate and short ridge-like thickenings.

The lamina is of a somewhat lighter color than the rachis, is generally 25 to 35 mm. in width and about twelve times as

long as wide. It is slightly narrowed both at base and apex. The lamina is longitudinally plicate with short wrinkles and linear thickenings. Since the plants are exposed to the beating of the surf portions of the lamina or even the entire lamina with a part of the rachis frequently become torn away.

Proliferations. — These occur on both rachis and lamina and arise as outgrowths of the merismatic area. These are the "leaves" or "laminæ" of authors. About four different kinds of proliferations may be distinguished. These are the ordinary spatulate or ovate or cuneate form, the branched laciniate form, the vesicle-bearing forms and the short cuneate gonidia-bearing form. (*Plate III., Figs. 1–27.*)

These short cuneate proliferations occur all along the margins of the rachis of old fronds scattered among the longer proliferations. In July not very many of the plants were actually producing gonidia, although these proliferations were present. Whether all of these are capable at some time of producing gonidangia is not known.

Areschoug speaks of "capillary" proliferations. These are probably the branched laciniate kind which in drying become much shrunken and could easily be called "capillary." The same author, who is followed by De Toni, describes the gonidiophylls as jugate. This is certainly not the case in fresh material. Kjellman[5] says that there are certain proliferations, like the usual spatulate form, except that they are irregularly ribbed, and that they bear the sporangia. This statement is quite incorrect. The gonidiophylls are always short, only 1 or 2 cm. long, while the ordinary proliferations are three or four times as long. Besides this they are not ribbed at all.

The proliferations of the lamina are always shorter than those of the stipe and air vesicles and gonidiophylls are never present on the lamina. The longest proliferations of any given branch occur near the region of growth between rachis and lamina, *i. e.*, as the branch becomes older it produces longer outgrowths. The longest proliferations of the lamina are usually from 4 to 6 cm. in length while those of the stipe are 9 to 12 cm. The branched proliferations are more abundant on the lamina than on the stipe.

Air vesicles, as indicated above, occur on the rachis, never on the lamina. They are the swollen and lengthened stalks of

otherwise ordinary proliferations and so are surmounted by spatulate or ovate-cuneate or branched leaf-like blades unless these be broken. The blades of these vesicle-bearing proliferations are often branched when those of neighboring proliferations are of the common form. The vesicles when fully grown are obovoidal or ellipsoidal, mostly 2.5 to 3.5 cm. in length. In the older parts of the rachis, as first described by Ruprecht, they are more bulged out, becoming nearly spherical and hence somewhat shorter. In the old vesicles the surmounting blade has always disappeared.

COMPARISON WITH OTHER LAMINARIACEÆ.

The morphology of the plant was not understood by early writers because of the fragmentary material studied. Turner and Agardh seem to have had only small portions of the stipe with no part of the lamina. Ruprecht apparently had good material. His *Plate IV.* is accurately drawn and shows both rachis and lamina. He, however, overlooked the branched laciniate proliferations; at any rate he does not show them in the drawing. Areschoug and De Toni seem to have neglected the work of Ruprecht. They do not mention the laminæ of the branches and so fail to show the morphological similarity of this plant with other Laminariaceæ. Professor Setchell[9] first pointed out the fact that *Egregia* conforms to the *Alaria* type in its morphology. It should be noted, however, that the plant body of *Egregia* shows a much higher degree of differentiation in the branching of the stipe and the character of the proliferations. In *Alaria* the proliferations occur only on the stipe. They are known as gonidiophylls. In *Egregia* only one kind of proliferations, the short somewhat cuneate form, bears gonidia. The others, both of the rachis and lamina, are sterile and should not be spoken of as gonidiophylls.

Egregia consists, as the other Laminariaceæ do, of holdfast, stipe and lamina, but the branching of the stipe gives rise to members (branches) each having the general characteristics of the entire frond in *Alaria*. The multiform proliferations largely replace functionally the lamina, which is here greatly reduced in size and importance. Because of the great elongation of the stipe a floating apparatus has become necessary and this is provided in the vesicles developed by the swelling of the stalks of certain proliferations.

Anatomy.

It will not be necessary to discuss at length the structure of other plants in the family Laminariaceæ. A rather full bibliography may be found in the recent articles by Professor MacMillan on *Nereocystis*[10] and *Lessonia*.[11]

It may be remarked that no special structural features were noted in *Egregia* which do not occur in other Laminariaceæ. Following Wille[12] the term trumpet hyphæ is used as synonymous with sieve tube, for Wille pointed out that the sieve tubes are merely old trumpet hyphæ. In *Egregia* there is no special sieve tube area at the periphery of the pith web such as has been described in other genera. There were no mucilage canals and no cryptostomata were seen.

At the present time only a somewhat general account will be given of the anatomy of *Egregia*. A more complete discussion of details of the anatomy and particularly the cytology will be given in a future paper.

Methods.—Material was hardened in chromic acid solution. The paraffin method of embedding was used and sections from 5 microns to 10 microns in thickness were cut. Staining on the slide was found most satisfactory, although some material was also stained in bulk. The sections were mounted from xylene into Canada balsam. By far the most useful double staining for general anatomical work was done with hæmatoxylin and Bismarck brown. Flemming's triple stain is also good.

Holdfast.—Each branch of the holdfast shows, on examination, an external cambium of thin-walled parenchymatous elements. An ill-defined cortex consists of three or four layers of cells similar to those of the epidermis. All these cells may contain an abundance of granular carbohydrate material. The pith comprising the chief part of the structure consists of more elongated cells, but with walls likewise thin. There is no mucilaginous thickening, nor are there well-developed trumpet hyphæ as in the pith of other parts of the plant.

Main stipe.—This is a short cylindrical structure, the branches of which form the rachides bearing the proliferations. The outermost ten or twelve layers of cells are thin-walled and merismatic. Next comes the cortical region in which the cells are prosenchymatous and have somewhat thick-

ened walls. The central part of the main stipe is a pith web consisting of more or less interlacing hyphæ, showing mucilaginous thickening of the walls. It is much the same as the pith web of the rachis and lamina.

Rachis.—This is a strap-like structure, rough-tuberculate on both surfaces. The elevations are to be considered as emergences consisting of cortical and hypodermal cells covered with epidermis. About one third of the entire thickness of the rachis is embraced in the pith web (*Fig. 28*). The epidermis consists of thin-walled prismatic cells with slightly thickened outer wall. Chlorophyll bodies are present here and in the hypoderma; the cells of the latter tissue resemble those of the epidermis in appearance (*Fig. 29*). There is a gradual transition to the cortex where the cells are thicker walled and elongated in the direction of the long axis of the rachis. Here chlorophyll bodies are absent. A somewhat well-marked limit is seen between cortex and pith web. The gelatinous thickening of the cell walls of the inner cortex gives an appearance of collenchyma (*Fig. 30*) when seen in cross section. A much greater development of gelatinous material occurs in the pith web (*Fig. 31*). In this region most of the hyphæ extend longitudinally, but there are many also passing horizontally and about as many in the direction of the thickness of the strap. Thus a section of the pith web, cut in any plane, will show the hyphæ extending in various directions; some may be followed for a distance, others are cut straight across and some obliquely.

Lamina.—This is very much roughened externally (*Plate II.*); numerous short plications extend longitudinally and also in part obliquely. The pith web is elevated at these places (*Fig. 32*), so that the emergences are deep-seated and not merely cortical as in the rachis. There are no other structural differences between lamina and rachis; epidermis, hypoderma, cortex and pith are essentially similar in the two regions. There is no real pith web in the proliferations, but the cells of the medullary region often show a certain amount of thickening (*Fig. 33*). The cells of the epidermis are generally short, but in some cases rather tall prismatic, just as in the main rachis and lamina. The tall prismatic cells are found regularly in the epidermis of young air vesicles (*Fig. 34*). The cells of the epidermis and hypoderma are frequently well filled with granular reserve carbohydrates. No important differences

were observed between the structure of the proliferations of the stipe and of the lamina. The gonidia-bearing proliferations bear gonidangia over the whole surface on both sides and on the edges. A small part of the broad blunt distal end is sterile. The gonidangia and paraphyses have the usual structure for members of the family as described by various observers.

Meristem.—The merismatic region between the rachis and lamina shows in its structure the same areas recognized in the older parts. The cell cavities of the pith web are rather large and become smaller with the mucilaginous thickening of the walls. All the cells of the merismatic area are quite thin-walled.

Summary and conclusions.—The morphology of *Egregia* is best understood if we consider it as an *Alaria* in which the stipe is branched close to the holdfast and each branch has taken on the characters of the entire shoot area of *Alaria*. Instead, however, of a few large proliferations of one kind borne on the stipe, *Egregia* has hundreds or thousands of small proliferations on both rachis and lamina. These proliferations are of various shapes. The stalks of some are swollen and hollow, forming air vesicles. These occur only on the rachis, never on the lamina. The gonidia-bearing proliferations are always small and rather cuneate in outline. Like the vesicles they are confined to the rachis. The laminæ are narrow and comparatively short, so the photosynthetic function develops chiefly on the proliferations. It is properly to display these that the development of vesicles has been necessary.

Egregia agrees rather closely with other Laminariaceæ in its anatomy. The stipe, rachis and lamina all show the usual areas, epidermal, hypodermal, cortical and medullary. The thickenings of the rachis and lamina are irregular multicellular emergences which in the lamina are above thickened places of the medulla (pith web), but which in the rachis are more superficial, consisting only of thickened areas of the other layers. The pith web is present in the main stipe but not in the branches of the holdfast. There is either no pith web in the proliferations or it is poorly developed. All of the proliferations have the same anatomical characters. An abundance of carbohydrate reserve material is usually present in the outer cells of the proliferations and also of other parts of the plant. In the structure of the gonidangia *Egregia* agrees with other

Laminariaceæ. Mucilage canals do not occur. No cryptostomata were seen.

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Explanation of Plates.

Plate I. The beach at low tide, Vancouver Island, at Minnesota Seaside Station. A large plant of *Egregia* is near the foreground; just back of it is placed a hat for comparison as to size. The plant is seen to consist in great part of very long strap-shaped branches with thousands of small proliferations along the sides. The plants in the foreground at the left are species of *Alaria*, those near the edge of the water in the background are *Lessonia*. Photographed by Hibbard.

Plate II. Photographs of young *Egregia* plants showing well the differences between rachis and lamina. Numerous vesicles may be seen on the rachis. These are the swollen bases of otherwise ordinary proliferations. Many of the proliferations of the lamina have been torn off. This is a common occurrence. These figures are about one half natural size. Photographed by Hibbard.

Plate III. 1–10. Proliferations of the lamina. 1–5. Common forms. 6, 7, 8. Forms occasionally met with. 9, 10. Forms somewhat numerous on old fronds. 11–27. Proliferations of the stipe. 11–17. Very common forms; those with vesicles (13–17) are not otherwise

different from 11 and 12. 18–26. Branched proliferations, some with, some without vesicles; the former are more often branched; thus 26 is more common than 25. 27. Group of gonidia-bearing proliferations, the part above the dotted line in each is sterile. All these figures were drawn from fresh material and are one half natural size.

Plate IV. 28–34. Drawings illustrating anatomical structure. 28. Diagram of a vertical section of the rachis, × 16; the emergences are seen to consist only of outer tissues, the pith web is about one third of the entire thickness of the rachis. 29. Longitudinal vertical section of the epidermis and the hypodermal region of the rachis from a section 5 microns thick; the outer walls of the epidermis are somewhat thickened, × 500. 30. Cross section through the inner cortex of the rachis, the thickened walls give the tissue the appearance of collenchyma, × 500. 31. Drawing of a portion of the pith web of the rachis. Some trumpet hyphæ are seen. The hyphæ extend in every direction and are cut in different ways. All the cells have gelatinous thickening of the walls, so that they appear as if in a gelatinous matrix, × 500. 32. Diagram of a vertical section of the lamina showing the thickening of the pith web below the emergences, × 16. 33. Cross section of a proliferation of the lamina; it will be seen that the cells in the middle of the structure are somewhat thick-walled. The epidermis here is composed of short prismatic cells, × 170. 34. Cross section of the wall of a small air vesicle. The epidermal cells are tall and prismatic in shape, the cells next the air cavity are somewhat thick-walled and rather flat; in older vesicles the epidermal cells are more flat, × 170.

PLATE I.

HELIOTYPE CO., BOSTON.

PLATE II.

HELIOTYPE CO., BOSTON.

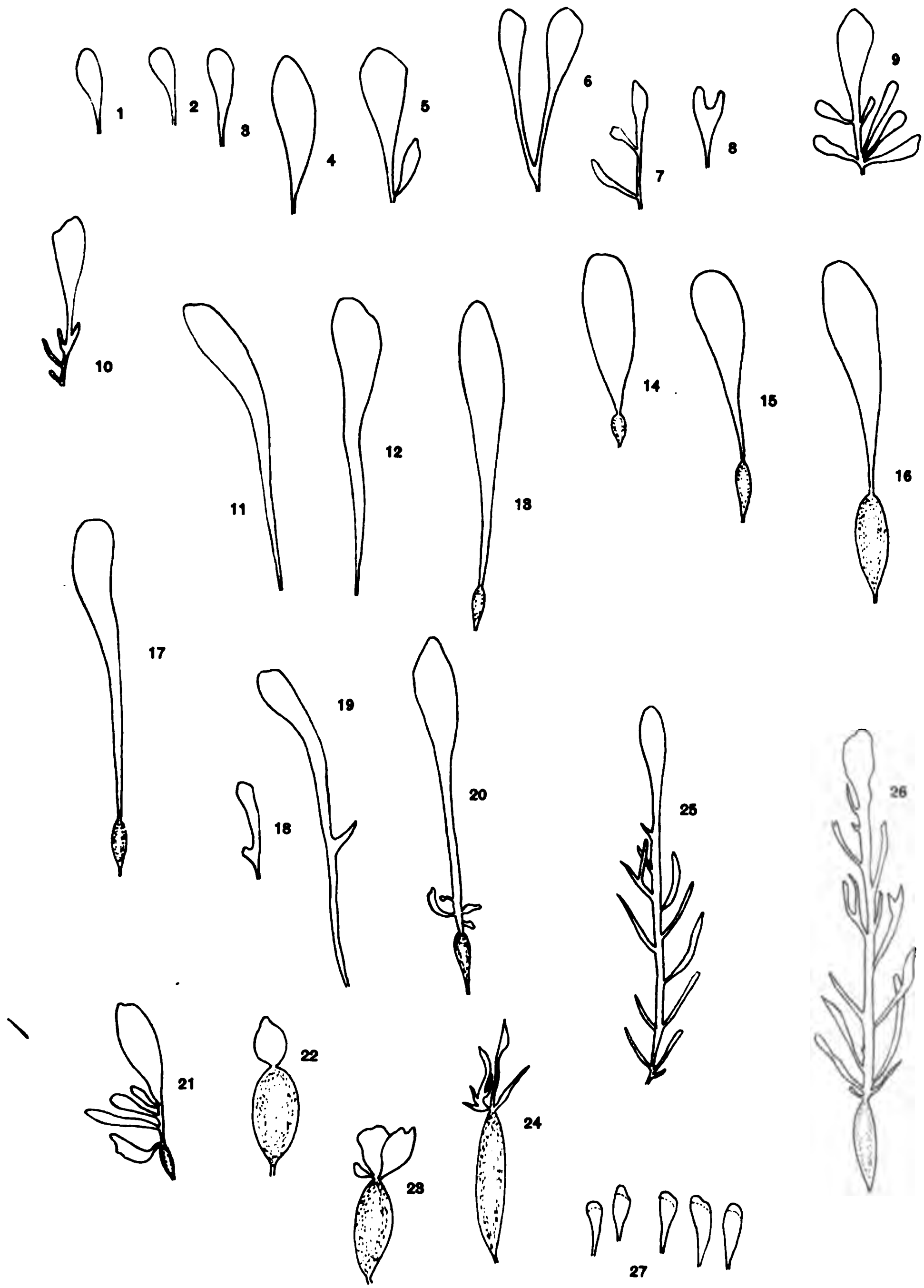


PLATE III.

HELIOTYPE CO., BOSTON.

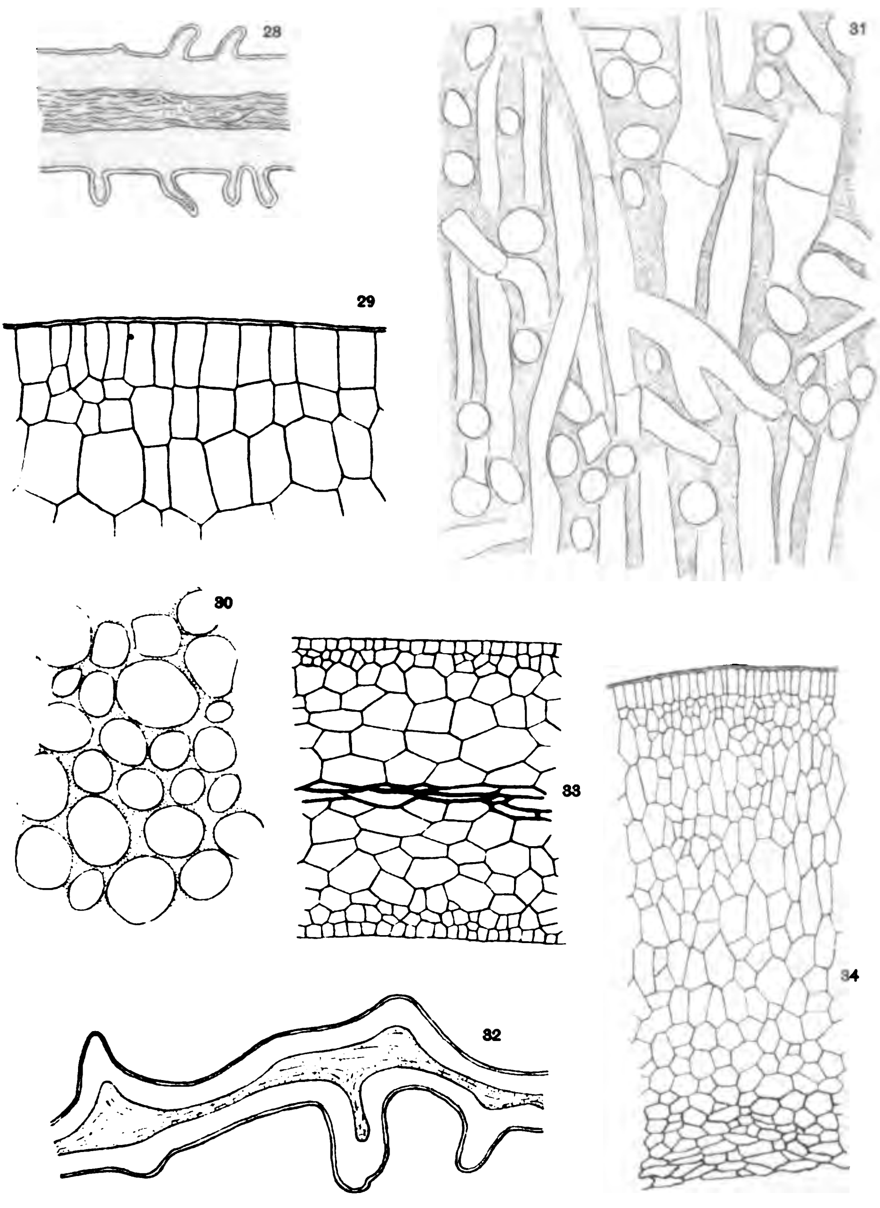


PLATE IV.

HELIOTYPE CO., BOSTON.

II. OBSERVATIONS ON TRICHOGLŒA LUBRICA.

FRED. K. BUTTERS.

The specimens of *Trichoglœa lubrica* (Harv.) J. Ag., upon which the following observations were made, were collected by Miss Josephine E. Tilden, June 13, 1900, at Kahuku point, at the northwest extremity of the island of Oahu, Hawaiian Islands, from material which had been cast up on the beach. Specimens from the same collection were subsequently distributed by the collector (American Algæ, Century V., No. 419) as *Nemalion ramolusum* Harv.

Several entire plants were preserved in a 1 per cent. solution of formaldehyde, and a small amount of material was killed in 1 per cent. chromic acid, and then, after thoroughly washing, transferred to 70 per cent. alcohol in which it was preserved. Material treated according to both of these methods was used in preparing the present paper. For most purposes the formaldehyde material proved more useful, as by this method the gelatinous matrix of the frond was preserved more nearly in its natural condition. In studying the microscopic anatomy it was found that many points could be best made out by picking to pieces portions of the frond with needles, or by crushing portions under the cover glass. The latter process was aided by the gelatinous nature of the frond. Besides preparations made by dissecting and crushing the frond, sections were made by various methods. For the study of the anatomy of the vegetative tract it was found that the best preparations were obtained by imbedding the material in celloidin, hardening the block with chloroform vapor, and cutting in the usual manner upon the sliding microtome. Sections were thus obtained in which the loose cortical structures were held in their proper positions. Useful preparations were made by mounting the material on a freezing chamber in a drop of gum arabic solution and cutting the frozen mass on the sliding microtome. This material did

not retain the cortical structures in place, but gave excellent results in the dense medullary region. Preparations were made also by imbedding the material in paraffin, and sectioning in the usual manner. By this means sections 6.66 microns in thickness were obtained. They were of little value in studying the vegetative tract, on account of the loose nature of the tissues involved, and the great shrinkage of the gelatinous matrix incident to this process, but they gave excellent preparations for the study of the later stages in the development of the cystocarp.

Gross Anatomy. — In the most perfect specimens the frond is vermiform and much branched (*Fig. 1*). About six main branches arise from a small disc-shaped holdfast. These main branches are repeatedly branched, pinnately and also dichotomously, and the ultimate branches are often furcate a short distance from the tip. The extreme length from the holdfast to the tip of the longest branch is 20 cm., the average height of the frond about 15 cm. The branches are 1–3 mm. in diameter, almost cylindrical, tapering gradually to about .5 mm. in diameter at the obtuse tip. The branches are very mobile and yield freely to the slightest motion of the water.

The whole thallus is gelatinous, and all parts of it, except the youngest growing portions of the branches, contain a considerable quantity of calcium carbonate which forms a white granular sheath about the medullary portion of each branch, and is itself surrounded by the outer cortical portion. According to the collector the color of the fresh frond was brownish-red, but all trace of color had disappeared in the preserved material.

Minute Structure of the Vegetative Tract. — The frond consists of two areas, a medullary portion and a cortical layer (*Plate V., Fig. 6*). Throughout the frond the filamentous structure of the tissues which is common among the Rhodophyceæ may be clearly distinguished. The filaments of cells lie imbedded in a general thin gelatinous matrix which is formed by the coalescence of the swollen gelatinous outer covering of the cells.

The medullary region consists of intermingled longitudinal filaments of two distinct types (*Figs. 6, 7*). The larger filaments are the primary filaments of the frond, and all other parts are derived from their lateral branching. They are composed of cells 120–1,300 mic. long and 12–120 mic. wide.

These cells are widest in their median portion, and are usually constricted at the ends. In the older portion of the frond they becomes highly vacuolate and finally almost devoid of contents, so that only the cell wall is capable of taking any appreciable stain.

Filaments of this type are occasionally unbranched for a considerable distance, but usually each filament gives rise to a series of lateral branches, of which one arises near the upper end of each cell of the filament. Occasionally, one of these lateral branches runs parallel to the parent filament to which it is in all respects similar, and so forms an additional medullary filament, but in most cases the lateral branch passes out perpendicularly into the peripheral region of the frond, and gives rise to a branch system of cortical filaments (*Figs. 3, 5*). In mature portions of the frond the primary filaments are often crowded together in the outer medullary region, forming a rather irregular hollow cylinder, within which are other more widely scattered primary filaments (*Fig. 6*).

Besides these larger filaments there are smaller filaments which run irregularly among the larger filaments (*Fig. 7*). These smaller filaments are composed of cells 45–140 mic. long, and 4–10 mic. in diameter, and the filaments are of nearly uniform diameter throughout, in which respect they differ from the larger filaments as well as in size. Their protoplasmic contents are more dense than those of the larger filaments.

These smaller filaments branch sparingly. They arise by the secondary branching of the cortical filaments, as will be described in detail in connection with the structure of the cortical portion of the frond.

The cortical area of the mature frond is composed of a complex branch system of filaments (*Figs. 4, 5*), and may be divided approximately into two regions, an outer or assimilating area, which forms the surface of the frond and consists of comparatively simple moniliform filaments, and an inner area which lies between the medulla and the assimilating area, and consists of intricately interwoven filaments of complex branching habit.

To appreciate the structure of the cortical area, its development must be understood. Examination of the growing point of the frond shows the dense medullary region, which here consists entirely of the large primary filaments, and surround-

ing this a cortex composed of almost unbranched filaments which run outwards from the medulla. At the extreme apex of the frond these cortical filaments are almost cylindrical throughout. Each one has a conical apical cell, and is evidently in active growth. A very short distance from the apex of the frond the distal cells of each filament are seen to have become nearly spherical, giving that portion of the filament a moniliform aspect, and thus the assimilating area is established. Apparently after the distal cells of a filament become thus matured it undergoes no further growth by cell division, but the proximal cells may increase very considerably in length. Soon secondary cortical filaments appear in the inner cortical region, arising by the proliferation of the primary cortical filaments. A secondary filament generally arises as a lateral outgrowth from the distal end of one of the cells of a primary filament. In all respects, except their origin, these secondary filaments exactly resemble the primary ones. They grow out among the latter for a time, and eventually mature, thus increasing the number of assimilating filaments. The secondary filaments may in turn give rise by proliferation to other similar filaments. Branching of the cortical filaments has already commenced in the lower part of the tip shown in *Fig. 2*. A few millimeters farther from the tip, branching will have gone much farther, and each of the original cortical filaments will have developed into a complicated branch system, as in *Fig. 3*, which shows two cells of a primary medullary filament, each of which bears a system of cortical filaments which has developed by the secondary branching of one simple cortical filament.

At about this stage in the growth of the frond, another kind of filament makes its appearance. Lateral outgrowths arise from the cells of the inner cortex, usually from their proximal portions (*S*, *Figs. 3, 5*). These outgrowths develop into cylindrical, almost simple filaments of much smaller diameter than the cortical filaments. The first of these filaments to appear in any cortical branch system is generally formed as an outgrowth from the proximal part of the basal cell of the system. These filaments are produced successively from the cells throughout the inner cortical region, and eventually the same cortical cell may give rise to several of them. They take an irregular course towards the medullary part of the frond, and eventually grow in among the large medullary filaments,

forming the smaller filaments of the medulla. Their general course after reaching the medullary region is approximately longitudinal and usually towards the base of the frond, but they sometimes turn upward toward the growing point, and a cross-section of the frond often shows them running in various oblique directions among the primary filaments (*Fig. 7*).

The production of the secondary cortical filaments and of these smaller medullary filaments continues for a long time, so that the branch systems become finally very intricate (*Fig. 4*). Even in the older parts of the frond immature cortical filaments may frequently be found among those which have long been mature (*Fig. 14*). In the mature frond there are somewhat large spaces among the cortical cells close to the medulla, and it is in these spaces that the calcium carbonate is deposited which incrusts the medullary region of the frond (*Fig. 6*).

In mature parts of the frond the diameter of the principal filaments of the inner cortical region is greatest close to their origin from the medullary filaments. The cells here average 65 x 12 mic. Farther from the medulla the cells are often longer, but more slender. Still farther out the cells are again shorter and wider, and pass by a gradual transition into the almost spherical cells of the assimilating area.

The outer cortical assimilating area of the frond consists of moniliform filaments, simple or somewhat sparingly branched in their proximal portions. In the region of transition from the inner cortex, the cells are somewhat elliptical, with an average size of 24 x 12 mic. In the distal parts of the filaments the cells are slightly wider and much shorter, so that they are almost spherical or often a little flattened, averaging about 14 x 15 mic. The terminal cell of a mature filament is usually somewhat smaller than the cells immediately proximal to it. In the maturation of a filament one or more of the distal cells frequently fail to round up, and finally break down, leaving the filament capped by a loose floating mass of material resulting from their deliquescence (*Fig. 14*).

The general structure of the frond is thus seen to agree closely with that which has been described in the nearly related genus *Liagora* (Agardh, J. G., Analecta Algologica, III., 96. 1896) and especially with that of the subgenus *Euliagora* (*l. c.*, p. 97). Agardh describes the structure of *Liagora viscida* (Forsk) J. Ag. as typical of this subgenus. He notes the two

kinds of medullary filaments, and says further, in describing the smaller filaments: "In partibus adhuc junioribus frondis sunt haec fila tenuiora longitudinalia, a quibus fila strati corticalis exeuntia observare, credidi." Specimens of a species of *Liagora* belonging to this subgenus, and probably *Liagora leprosa* (Tilden, Josephine E., American Algæ, Century V., 417), have been examined in connection with the preparation of the present article, and in them the origin of the smaller medullary filaments was found to be identical with that in *Trichoglœa lubrica*. It is easy to see how the mutual relationship of the cortical and the smaller medullary filaments might be misunderstood, and it is suggested that further observations may show the smaller medullary filaments to be of cortical origin in the other species of *Liagora*, also.

Cytology of the vegetative tract. — In material stained with acid fuchsin, or with anilin-water-safranin the nuclei appear as nearly spherical densely staining bodies. With the exception of the cells of the larger medullary filaments, in which no satisfactory nuclear stains were obtained, each cell contains a single centrally located nucleus. The nuclei of the outer cortical cells are 2–5 mic. in diameter, those of the other parts of the frond generally somewhat smaller. None of the material was preserved with intention to show division stages of the nuclei.

Surrounding the nucleus and lying close to the outside of the cell is the chromatophore. This body is irregularly ring-shaped, with processes running inward towards the nucleus. In the spherical cells of the outer cortex the chromatophore almost fills the cell, but in the more elongated cells of the inner cortex, it forms a comparatively narrow band about the center of each cell. As it stains heavily with acid fuchsin, it often entirely conceals the nucleus, so that, especially in the outer cortex, the nuclei can be studied to advantage only in sectional material. In the vicinity of the chromatophore there is often a deposit of floridean starch. This is most abundant in the special photosynthetic cells, but is found also in other cells which contain a chromatophore. The cells of the smaller medullary filaments resemble those of the cortical filaments except in shape. They have a very narrow chromatophore. The cells of the large medullary filaments have no chromatophore and no distinctly staining nucleus was seen in them.

Throughout the frond the cytoplasmic strands between the adjacent cells of a filament are evident. In some cases these may be seen in unstained material, and in preparations stained with a solution of iodine in water and potassium iodide they are easily visible in all parts of the plant.

With iodine-potassium-iodide solution and sulphuric acid the cell walls give a faint cellulose reaction, stronger in the medullary region than in the cortex. In the cells of the medulla and inner cortex, in preparations stained with acid fuchsin, a ring of more densely staining cell wall is seen between adjacent cells, surrounding the protoplasmic connection between the cells. This ring does not display the cellulose reaction with iodine and sulphuric acid and is not stained with the chlor-zinc-iodide callus reagent.

Several reagents, such as gentian-violet and bismarck-brown, stained the gelatinous matrix of the frond. In some sections, stained with bismarck-brown, it was possible to make out the structure of the matrix, a definite portion of it being seen as a sheath surrounding each of the cortical filaments.

The reproductive tract.—Both antheridia and procarps were found upon the plants which were examined. There is often a localization of these organs, so that an entire branch of the frond may be male or female, but more often both kinds of reproductive organs are produced close together upon the same branch of the frond and often upon adjacent groups of cortical filaments springing from the same medullary filament, but apparently never upon the same branch system of cortical filaments.

The antheridia.—Antheridia arise by the proliferation of the distal cells of a peripheral filament (*Figs. 5, 8*). The distal cells in this case average 9 x 6 mic., being smaller than the immediately proximal sterile cells and smaller than the distal cells of mature sterile filaments. They are devoid of floridean starch, while the immediately proximal sterile cells are filled with it. These central cells of the antheridial branch bear numerous simple or branched chains of almost spherical, somewhat thick-walled cells about 2.8 mic. in diameter. The terminal cells of these chains are the sperm mother cells and when they are mature each one discharges its sperm from the enclosing cell wall. The sperms are the usual spherical non-motile sperms of the Florideæ.

The procarp and cystocarp.—Procarps are borne terminally on cortical filaments having the aspect of the ordinary immature filaments of that area. They were never found produced by the primary cortical filaments of the growing point, but they are often borne on some of the earlier formed secondary filaments and are often abundant a very short distance behind the growing tip of a branch. They are also often produced on the younger filaments of much older cortical branch systems, and it is not uncommon to find procarps and mature cystocarps close together in the same branch system of cortical filaments. In the development of the procarp the wall of the terminal cell of a young cortical filament becomes thickened, particularly about the distal parts of the cell, and a terminal cylindrical outgrowth appears (*Figs. 9, 10*). This outgrowth, the trichogyne, increases in length until, in the mature procarp, it may reach 150 mic. in length, projecting beyond the gelatinous matrix of the frond. In all immature procarps the protoplasm of the trichogyne was continuous with that of the carpogonial cell. No entirely mature and unfecundated procarps were seen. Many mature procarps with attached sperms were found, and in these the protoplasmic contents of the trichogyne were always much constricted and often broken at intervals and separated from the contents of the carpogonial cell.

The carpogonial cell and the trichogyne are from the first devoid of floridean starch.

The cell immediately proximal to the carpogonial cell is specialized as an auxiliary stalk cell (*Figs. 10–16, a*). During the earlier stages of the development of the trichogyne, the cell is scarcely to be distinguished from the sterile cells of the filament. As the trichogyne approaches maturity the auxiliary stalk cell rounds up, becoming wider than the adjacent cells, and it may be further distinguished from the proximal celis of the filament by its dense cytoplasm, and by containing very little floridean starch. It undergoes little further change during the development of the cystocarp.

After fecundation the trichogyne soon withers, but the basal portion may persist for a considerable time (*Fig. 14*). Its remains may occasionally be seen in the half developed cystocarp, but never when the cystocarp is mature.

The fecundated carpogonial cell soon divides transversely into two unlike cells. The proximal cell thus formed is almost

cylindrical, averaging 10.7 x 8.6 mic. It remains sterile, forming a stalk cell, or placenta (*Figs. 12–16, S*). It contains a distinct nucleus, and has thin cytoplasm, appearing noticeably clearer than the adjacent cells. Its cell wall is often much thicker than that of the auxiliary stalk cell, or of the central cells of the cystocarp. Throughout the development of the cystocarp the cytoplasmic connections between the proximal cells of the fertile filament, the auxiliary stalk-cell, the stalk-cell, and the basal fertile cells of the cystocarp can be easily seen.

The distal cell formed by the first division of the carpogonial cell has very dense cytoplasm (*Fig. 12, c*). It soon divides again, transversely, and then each of the cells thus formed divides one or more times in planes perpendicular to the first division, forming thus an almost spherical mass of several cells arranged in two tiers (*Figs. 13, 14*). These form the central cells of the cystocarp. Branching gonimoblast filaments arise as outgrowths of these central cells (*Figs. 15, 17*). The cortical cells of the gonimoblast are very thin walled, and have dense cytoplasm and distinct nuclei. When the gonimoblast filaments reach their full growth the terminal cells become thick-walled, and their cytoplasm becomes very dense. Eventually the contents of each of these cells escapes as a spore, leaving the empty cell-wall still attached to the gonimoblast filament.

As a secondary result of the fecundation of the procarp, sterile filaments, resembling the ordinary cortical filaments, arise from the cells immediately proximal to the auxiliary stalk-cell. These filaments correspond to the pericarp which completely surrounds the cystocarp of many Rhodophyceæ, but in this case they never form more than an irregular and imperfect covering about the base of the cystocarp.

It will be seen that the structure and development of the cystocarp is essentially that found throughout the Nemalieæ. The general features of the reproduction in this group were described by Bornet and Thuret in the year 1867 (Bornet, E., and Thuret, G., Recherches sur la fecundation des Floridées, Annales des Sciences Naturelles, Series V., 8: 141–145. 1867) sincewhich time the phenomena of reproduction have been studied more or less in detail in numerous plants of this group. (See Janczewski, Notes sur le Developpement du Cystocarp dans les Floridees,

Mem. de la Soc. de Cherbourg, **20**: 109–144. 1876; Bornet, E., and Thuret, G., Etudes Phycologiques, 63, *Plate 32*, 1878; Wille, N., Die Befruchtung von *Nemalion multifidum* (Web. and Mohr) J. Ag., Berichte der Deut. Bot. Ges. **12**: (57). 1894.) In *Nemalion multifidum* Wille (*l. c.*) traced the passage of the male nucleus down into the carpogonial cell, and its fusion with the nucleus of the latter.

Schmitz and Hauptfleisch (Schmitz, Fr., and Hauptfleisch, P., Helmenthocladiaceæ, in Engler and Prantl, Die Natürlichen Pflanzenfamilien) in their classification of the Nemalieæ lay stress on the position of the carpogonial branch, whether it is terminal on one of the younger cortical filaments, or borne laterally upon one of the intermediate cells of a cortical filament. In this they are followed by De Toni. (De Toni, J. B., Sylloge Algarum, **12**: 76. 1897.) In the first class they place *Nemalion* and *Trichoglœa*, and in the second class *Helminthocladia* and *Liagora*. It is to be noted that, while the procarp appears terminal in *Trichoglœa lubrica*, it is borne only on one of the secondary filaments, which are themselves of lateral origin, and hence the difference in this case is rather that the carpogonial branch in *Trichoglœa* is long, approaching the length of the sterile cortical filaments, while in *Liagora* and its allies the carpogonial branch is very short, and hence the procarp is almost sessile. Whether the apparently terminal procarp of *Nemalion* is to be similarly interpreted, can be determined only by observation.

It has been noted that in *Trichoglœa lubrica* there is a rudimentary pericarp. In *Nemalion* the cystocarp is naked, while in the other genera of the Nemalieæ there is an abundant pericarp, often produced by outgrowths from the primary cortical filament upon which the carpogonial branch stands.

It will thus be seen that in the structure of the vegetative tract *Trichoglœa lubrica* agrees very closely with the genus *Liagora*, while in the reproductive tract (and especially in the structure of the cystocarps), it most nearly resembles *Nemalion*, holding, however, in some respects a position intermediate between *Nemalion* and the three genera, *Liagora*, *Helminthocladia* and *Helminthora*.

Explanation of Plates.

The figures on Plate V. are from photographs and photomicrographs, those in Plate VI. are from drawings made with the Abbé camera.

1. Entire plant of *Trichoglœa lubrica* (Harv.) J. Ag., about three fourths natural size. After photograph by C. J. Hibbard.

2. The growing point of a branch of the frond, × 120.

3. Detail from somewhat older portion of the frond, × 65. *p*, primary medullary filament; *s*, one of the smaller medullary filaments; *s'*, a younger filament of the same type; *c*, young cystocarp.

4 A single mature cortical branch system, × 25.

5. An antheridial cortical branch system, × 80. *p*, primary medullary filament; *s*, one of the smaller medullary filaments; *s'*, a younger filament of the same type; *c*, young cystocarp.

6. Cross-section of mature portion of frond, × 32. Part of the calcareous incrustation has been removed with hydrochloric acid. *l*, remains of the deposit of lime.

7. Detail from cross-section of medullary region of mature frond showing the two kinds of medullary filaments, × 116.

8. Detail of antheridial cortical filament, × 438.

9–16. Stages in the development of the protocarp and cystocarp. *a*, auxiliary stalk-cell; *s*, stalk-cell; *c*, fertile portion of carpogonial cell after the cutting off of the stalk-cell.

9. Young procarp, × 600.

10. Procarp with the trichogyne about half developed, × 475.

11. Mature and fecundated procarp, × 475.

12. Carpogonial branch after the first division of the carpogonial cell, × 600.

13. A somewhat later stage in the development of the cystocarp, × 700.

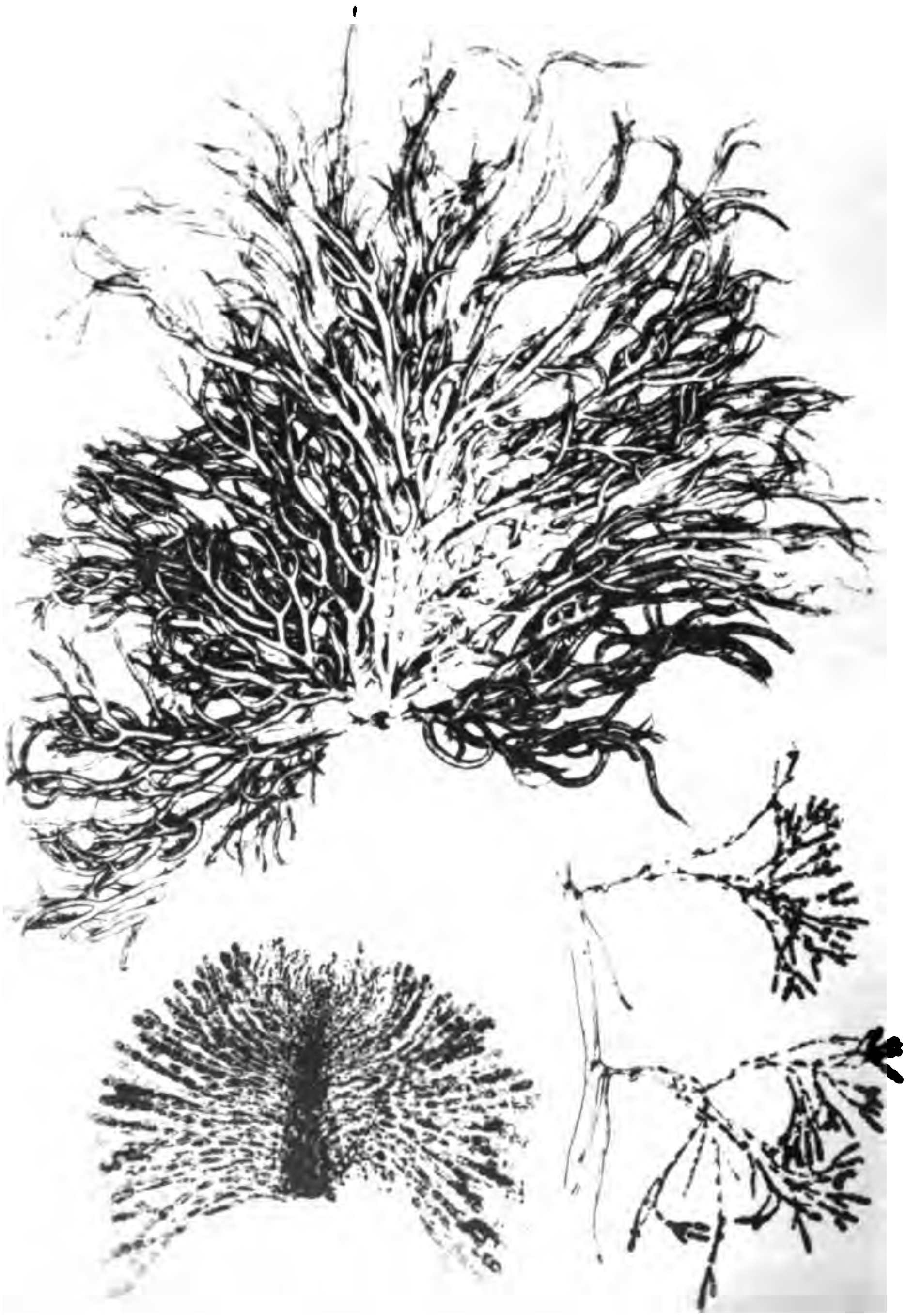
The distal segment of the carpogonial cell has divided a second time transversely, and the segments are dividing longitudinally. The growth of pericarp filaments has begun.

14. A developing cystocarp, slightly later stage than *Fig. 13*, in position among the surrounding cortical filaments, × 400.

15. Young cystocarp with the developing gonimoblast, × 475.

16. Mature cystocarp, × 438. From section 6.66 mic. thick.

17. Detail of developing gonimoblast, × 640.



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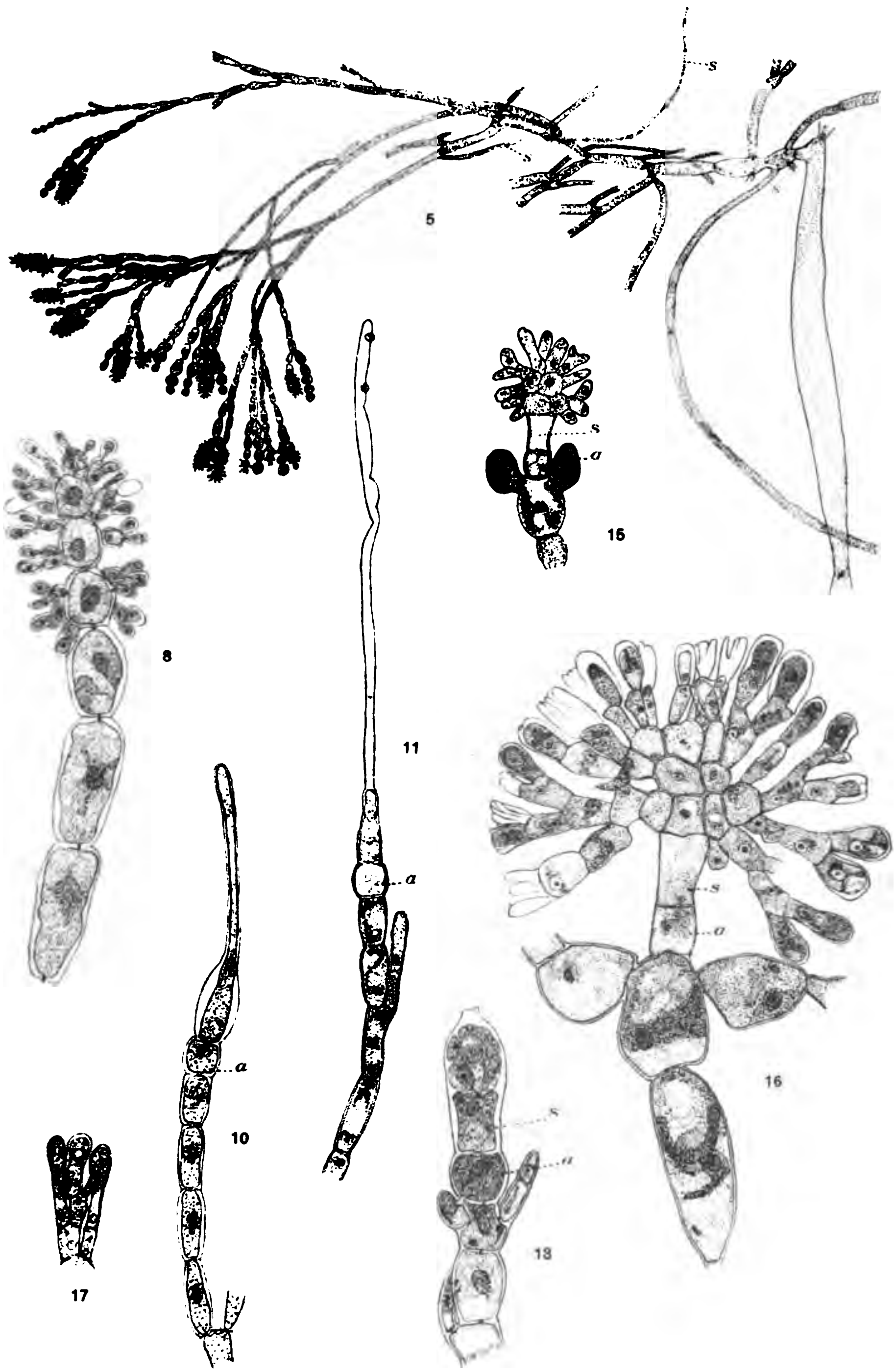

PLATE VI.

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III. OBSERVATIONS ON PELVETIA.

F. L. HOLTZ.

Pelvetia fastigiata (J. Ag.) DeToni, is a marine alga found distributed along the western coast of the United States and British Columbia. It grows in beds, attached to the rocks, between high and mid tide, and is, therefore, daily exposed to the air for several hours (*Pl. VIII.*). The material studied for this paper was collected by Miss Josephine E. Tilden on Vancouver Island, in June, August, and December, 1901, and was preserved in formalin.

There was originally some doubt in the minds of systematists whether this plant was a *Pelvetia*. It has been called *Fucus fastigiatum* (J. Agardh, Symb., I., 3) and *Fucodium fastigiatum* (J. Agardh, Sp., I., 203). The difficulty of placing it arose from the uncertainty as to the number of eggs it forms in the oögone, and this point was left undecided by DeToni. Dr. W. A. Setchell seems to have been the first to demonstrate the true generic position.*

External appearance.—*Pelvetia* is one of the smaller wracks. It is 10–20 cm. in height, and springs from a disc-shaped holdfast with dichotomous branches repeated till it presents a fascicled appearance. In well-developed plants the stipe branches immediately above the holdfast, and the branches subdivide again but a short distance farther on, so that at first sight there seems to be several fronds arising from the same holdfast. The regular dichotomy near the base may be further confused by adventitious shoots springing from near the base of the main stipe. In the material at hand but one main stipe was observed arising from a holdfast. The front may undergo dichotomy a dozen times before the terminal laminæ are reached. The internodes are longer toward the top. The coördinate branches keep about equal growth, though a few may remain smaller and hence appear like lateral branches (*Pl. VII.*).

*Setchell, W. A. Phyc. Bor. Am., No. 176.

The holdfast is a disc about 1 cm. across, and may be somewhat lobed at its margin, due to protruding masses of cells that are somewhat rhizoid in function, tending to clasp the irregularities of the substratum. The under surface appears slightly rough and pitted.

The mature stipe is elliptical in cross-section, but not winged. It is thicker and rounder at the holdfast, but flattens out into a ribbon-like shape farther up, and widens and thickens slightly toward the top. The average width at the bottom is 3 mm., and at the top 4 mm. It is about 1 mm. thick at the base and 2 to 3 mm. at the top. It is tough and coriaceous below, soft and fleshy above.

The laminal portion is usually two-lobed, and is differentiated externally from the stipe by a rather abrupt thickening and by the fact that it is generally dotted over with the elevated ostioles of the conceptacles, giving it a warty appearance. The lamina is also more translucent than the stipe. The lamina is wedge-shaped; the lobes into which it is divided in its upper half are tapering with rounded points. The laminæ have the softest tissue in the plant. There are usually laminæ in all stages of development, on a main branch, from cylindrical stipe-like laminæ to old, flat, warty, fruiting ones.

The color of the plant is nearly uniformly light brown, the older parts being a little darker, especially the lower stipe. The surface, except on the fruiting lobes, is smooth and shining. The plant is very elastic.

Adventitious shoots may arise on any part of the surface of the plant. They occur chiefly where old wounds have healed over. For instance, where a branch has been torn of, or a lamina cut off, or where incisions have occurred, here may be found proliferations arising as small outgrowths. Sometimes only one may occur, again a dense cluster. Some of these develop into large shoots.

The conceptacles may easily be seen by looking through the translucent lamina toward a strong light. They are thickly scattered over the lamina and its lobes. There is a rude arrangement of the conceptacles in rows running approximately perpendicularly across the axes of the lobes. There are 150 to 200 conceptacles on a lamina. They are developed in the younger tissue at the ends of the lamina lobes. Hence the more mature conceptacles are found some distance from the tip

of the lobe. Occasionally conceptacles are scattered over the stipe. These are generally less mature than those on the lamina above. They may be formed here adventitiously after those of the lamina, or else they may have been formed before or at the same time as those on the lamina and were then arrested in their growth.

The conceptacles cause a small papilla in the surface above them. This can be easily seen with the naked eye, as can also the ostioles themselves, which appear as little pits in the tops of the papillæ. A well-developed plant may have half a dozen main branches and fifty to sixty laminæ.

When placed in fresh water the mucilage of the interior of the plant absorbing the water, causes the laminæ to burst. The distending pith pushes its way out and the cortex curls back, showing a state of tension between interior and exterior. As a result the cortex pulls off from the pith. The conceptacles then appear plainly as little spherical masses projecting from the inner side of the cortex. This intimate union of the conceptacle with the cortex might be taken as evidence of the cortical origin of the conceptacles, which is the case, as will be shown. In *Plate VII* conceptacles are visible on the inside of the cortex in the bursted laminæ.

Minute anatomy, tissues in general.—*Pelvetia* shows considerable differentiation of tissues, though not so much as many other algæ, not even so much as some of the other Fucaceæ. *Fucus* shows greater differentiation in having a midrib and air vesicles in addition to the structures possessed by *Pelvetia fastigiata*.

There are three principal tissues in the body of the plant. The epidermis, cortex and pith comprise the main bulk of the body. In the holdfast, however, no real pith cells are found.

Epidermis.—The epidermal tissue of *Pelvetia fastigiata* consists of a layer of prismatic cells elongated radially to about twice their shorter diameters, which are about equal. The epidermis is best developed in the stipe and lamina. Seen here in surface view the cells present a roughly quadrangular or polygonal outline. The epidermis is shown in longitudinal and cross-sections in *Figs. 1–3, Pl. IX.* The inner end of the epidermal cells and their radial walls are thin, while their free surface walls are convex outward. The surface of the epidermis is covered with a cuticle, thick and striated. This

cuticle is a common sheath to the whole plant. It is depressed into the crevices between the cells and is therefore wavy in section. It peels off in places. It shows a different, generally weaker, staining reaction from the regular cell wall. The wall underneath the cuticle is thin. The cuticularized epidermis probably is useful in preventing evaporation when the plant is exposed between tides. The hygroscopic nature of the mucilage within no doubt plays a very important part in this respect.

The epidermal cells are densely gorged with chromatophores. These are yellow, highly refracting grains of oval shape. As the function of the epidermis is assimilative as well as protective, the question arises, may not the convex outer walls of the cells aid in condensing the light that is necessary for assimilation (Kerner)?

The epidermal cells have the power of dividing radially and periclinally, cutting off basal cells that are added to the cortex and cause growth in thickness. The division in planes transverse to the axis of the plant provides for the elongation of the plant. This cambium-like nature of the epidermal cells is also seen in the origination of a meristematic layer where a conceptacle is to be produced (*Pl. XI., Fig. 17*), and again the growing point is an epidermal cell (*Pl. X.*).

Cortex.—(*Pl. IX., Figs. 1–3, 5.*) Below the epidermis are six or seven rows of cells of varying size and nature, differing more or less from the epidermal and pith cells, and agreeing in a general way in not being greatly elongated and in having a large number of chromatophores. This tissue is the cortex. (The epidermis is by some writers included under this name.) The cells of the cortex are arranged with considerable regularity in vertical, radial and concentric rows. The regularity of shape and size tends to diminish towards the pith.

The row of cells immediately beneath the epidermis is composed of the basal cutoffs from the epidermal cells. They are cuboidal cells of a diameter equal to the width of the epidermal cells. They, like the outer cells, are gorged with color bodies. The second and third concentric rows of the cortex are, in cross section, of equal diameter, but a little larger than the row above. In longitudinal section it is seen that these cells are generally respectively two and four times as long as the basal cells of the epidermis. Some of the cells also show this larger size in cross-section. These cells seem still to have the power

of growth; and to some extent they divide both radially and vertically, but not tangentially. These two rows of cells also have rather thin walls, although there is some thickening at the angles. They are also densely packed with chromatophores.

Below the above-mentioned cells are three or four (five) concentric rows of cells that pass over into the pith on the inner side. Their walls are considerably thickened with a gelatinous substance, which, however, is firmer and denser than that of the pith. These walls stain deeply. The cells of these rows contain color grains but in more loosely disposed masses. The protoplasmic sac is more easily seen around these masses of chromatophores than in the outer cells. These cells have nearly the same radial diameter as the cells in the second and third rows, but are generally twice as wide tangentially and twice as long vertically as those of the third row. There is more or less variation in the number of rows of each of these different sizes of cells. These elements may be diagrammatized as in *Pl. IX., Fig. 5.*

The original walls between these cells thicken as the pith is approached. The cells lose their rectangular shape more and more towards the pith till at last it is sometimes difficult to distinguish them from the more cylindrical pith cells. The cells remain in communication through pits, the cells anastomosing frequently. The longer cells form transverse septa, which are often oblique to the lateral walls. These septa are never thickened, but remain very thin and, to all appearance, allow protoplasmic communication (*Pl. IX., Fig. 12*).

Pith.—(*Pl. IX., Figs. 1–5.*) The pith of the stipe and lamina is distinguished by the fact that the cells are separated widely by intercellular jelly, which in the lamina is from two to three times as thick as the diameter of the cells imbedded in it, less thick in the stipe (1–2). The pith is also marked off by the jelly not staining as deeply as the intercellular matrix in the cortex. With some stains, fuchsine for example, the stain may be almost completely removed by washing, leaving the inner wall of the pith cells colored. Pith cells are slightly compressed corresponding with the flattening of the stipe or lamina (*Pl. IX., Fig. 1*). They are nearly as wide as the average width of the cortex cells, and are about as long or a trifle longer than these. They are crossed by delicate septa (*Pl. IX., Figs. 2, 4, 13*). Pith cells are joined into vertical rows or filaments

which wind about and intertwine somewhat with each other. These filaments anastomose frequently and are often dichotomously divided (*Pl. IX., Figs. 3, 4, 13*). The cells of the pith in the central part of the stipe or blade are of nearly uniform diameter throughout their length and are regular in shape, except at anastomosing plexi and near the cortex where they are subject to distortion in shape and to displacement.

The pith cells contain a few chromatophores collected into a little pellet near the middle of the cell. The protoplasmic contents show up well and numerous refracting grains of reserve material are seen.

The gelatinous intercellular matrix swells up greatly when the plant is placed in fresh water. This causes the lamina to burst open, beginning at the more tender tip of the lobes in the young laminæ. The stipe having a firmer cortex and also proportionately less intercellular gelatine, does not burst, though it swells some.

Anastomosis and Pits.—Anastomosis is seen best in the pith cells (*Pl. IX., Figs. 2–4, 12–14*). Sometimes two filaments will simply be bent toward each other, touching with their convexities (*Fig. 2*). At this point there is no intercellular jelly separating the cells. A thin communicating plate is between the cells in contact, and the protoplasm in these cells sends out branches that meet at the plate. At other times the anastomosing cells send out lateral protuberances, which passing through the jelly, meet and form a pit at the point of contact (*Figs. 4, 13, 14*). Probably these protuberances were not formed before the pit was formed, but are the result of the growth and modification of shape of the cells which took place after the pit already was made. Judging from the conditions in the cortical layers, these pits are simply the original fission walls left unthickened at these spots (*Fig. 12*), while at other points the contiguous cells were forced apart by the development of the gelatinous middle lamella between the two cells, however, leaving the cells in contact at the pits. The pits at lateral anastomosing points are smaller than at the ends of the vertical cells. The pits do not stain as deeply as the rest of the cell wall, but this might be due to their greater thinness. They are sharply marked off in the walls of the pith and the inner cortex cells. They are round or oval plates which in optical section are of uniform thickness, not lenticular. They show less definition of

shape as the outer cells of the cortex are approached. Here they appear to be simply the original dividing wall. They can, however, be located by the protoplasm apparently running right through the wall at these places. This apparent communication of the protoplasm of adjoining cells was observed as far out as the second layer of cells below the epidermis. Farther out this could not be seen on account of the chromatophores. But probably even the epidermal cells communicate with each other. The concentrated sulphuric acid test showed that the plates were dissolved as well as the rest of the wall. No positive proof was found that the pits were perforated, no threads of protoplasm having been observed, as would indeed be difficult with the extreme thinness of the plates. But the symmetrical arrangement or attachment of the protoplasm on both sides of the pits leads one to suspect very strongly that there is communication. By plasmolysis the protoplasm draws away from the cell wall at all other points than the pits (*Fig. 13*). It remains attached here and extends in ropes through the cells and seemingly through the pits. The protoplasm often branches to lateral pits (*Fig. 14*). When the pith cells are swollen in fresh water the protoplasm is frequently torn off from one end of the cell, away from a pit, owing apparently to the elongation of the lateral wall as well as the gelatinous matrix. In such cases the pit curves in toward the loosened protoplasm (*Figs. 12, 14*).

Iodine is the most satisfactory stain to use in studying pits. The protoplasm is stained and its attachments may be studied. Pits and anastomosis may be nicely studied by removing some of the protruding pith from a lamina that has burst in fresh water. By flattening the gelatinous mass under the cover glass the pith cells and their pits show up well, even unstained, though better if differentiated with stains for walls and for protoplasm.

Anatomy of Holdfast, Stipe and Lamina. — The above matter on the tissues in the body of *P. fastigiata* needs some modification and addition when the holdfast, stipe and lamina are considered separately.

Holdfast. — In a vertical section through a holdfast it is seen to be composed of approximately regular, ascending rows of cells; those near the central part more vertical; those near the border of the holdfast curving out as they go down. There is a marked difference between the cells in the middle and those

in the peripheral part. The former are irregularly quadrangular in outline in both vertical and cross-section. Their diameters in cross-section are equal (*Fig. 6*). They are more regularly disposed in rows than the cells in the marginal parts. The cells of the holdfast have walls of good thickness, composed in part of the usual mucilaginous substance.

Taking the central part of the holdfast (*Fig. 6*), the lowest cells are dead and empty and partially disintegrated into mucilage. Clefts arise among the still living cells from this disintegration. Gaps are also caused in this way in the body of the holdfast. Here and there individual cells at the bottom have a disc-like lower surface as if they had a holdfast of their own. The decay of the cells near the central part of the holdfast extends not more than one or two cells deep. The next few rows of cells are slightly flattened parallel with the base of the holdfast. The succeeding rows of cells become gradually elongated in a vertical direction till, at the tenth or eleventh row, a rapid differentiation begins with cells elongated in the vertical direction to two or four times their horizontal diameter. Evidently the stipe begins at this zone.

The peripheral portion (*Fig. 7*), as was stated above, is composed of rows of cells descending obliquely from the axis of the stipe. A vertical section through this part shows that these rows of cells branch dichotomously in the horizontal plane as they go down and outward. The cells decrease in length as one follows the dividing branches, till a zone is reached in what corresponds to the cortex of the stipe. Here the ultimate dichotomous divisions of the main strands form a meristem of small cells. The cells of this meristem run in straight rows perpendicularly to the surface of the holdfast. They are in active division. This meristematic layer enables the holdfast to grow in thickness and also to form the rhizoid-flaps on its edge. It is about eight to ten cells deep. In the specimen examined the basal cells, three to five deep in this part of the holdfast, showed advanced disintegration. The epidermal layer near the lower edge also was in a similar condition. But the cells of this layer are more resisting and persist alive after the two rows beneath are already dead. Probably the mucilage derived from the disintegration of these basal cells is useful in attaching the plant to the substratum.

The cortical part of the holdfast passes without any marked change into that of the stipe. The epidermal cells however are not elongated as much radially as those of the other parts of the surface of the plant. It is covered with a cuticle, thicker than on the stipe or lamina.

Cross-sections of the central part of the holdfast show (*Fig. 8*) that the vertical rows of cells seen on vertical section are not disposed in any regular order. The intercellular substance is not nearly as abundant as in the stipe. Toward the margin of the holdfast the cells show power of dividing. Here we find, interspersed with cross-sections of the vertical rows, sections through cell rows slanting up toward the axis of the plant. Still nearer the outside we come upon the meristematic zone. Here are principally slanting rows of cells dividing dichotomously in the radial direction. These divisions repeat the dichotomy, running directly to the surface.

All the living cells in the holdfast have chromatophores. The central cells contain but few grains, the cortical are crowded with them.

Stipe.—But little need be added here to what has been said under tissues in general. The young stipe has a nearly cylindrical structure, with a slight notch on the end where a growing point is situated. No differentiation is noticeable between stipe and lamina. Older stipes become flattened, partly on account of the flattening of the cells parallel with the longer axis of the cross-section, but more on account of the greater growth toward the thin margins. A cross-section of an older stipe shows two principal planes of fission by the arrangement of the cells in rows parallel with the major axis of the section and the other obliquely across this axis. This is especially noticeable in the pith. The cortical cells show a distinctly concentric arrangement (*Fig. 1*).

The only differentiation seen in cross-section is that the pith and inner cortex cells near the ends of the ellipse are somewhat larger than those of the central part. This differentiation however does not even suggest a midrib. Longitudinal sections of the stipe, cut parallel to the flat surface, show a similar appearance, except that the typical pith cells are reached sooner in passing from the surface along the minor axis. The appearance of the cells in both cross and longitudinal sections has been discussed under tissues in general.

Lamina.—The general tissues of the stipe and lamina are so

similar that no change is noticeable in passing from one to the other. In the lamina proper, however, the pith cells branch more and the rows of cells have a more meandering course, and there is more anastomosing. The intercellular jelly is developed here more than elsewhere in the plant. Due to this and some to the branching of the cell rows the blade is much thicker than the stipe.

The cortex and epidermis are similar to those of the stipe. The crowding growth of the conceptacles disarranges the orderliness of the cell arrangement in the cortex and epidermis. Cross and longitudinal sections of the lamina resemble those of the stalk closely, except for the differences just mentioned, and for the conceptacles (*Fig. 3* shows a partial cross-section of a lamina).

The growing point.—In the tip of the maturer laminæ no definite growing point can be found. There still is some growth and cell division going on here in the outer cortical cells, and in a mature lamina this is probably the youngest and tenderest portion. It is here that the lamina begins to burst when placed in fresh water. Even at the sinus between the lobes of the lamina no growing point can be found in older laminæ. This is the place where the growing point once was. But the growth seems to have stopped here first and continues for a time longer toward the ends of the lobes.

If a young frond is examined, one in which there is as yet no difference between stem and blade, a slight notch or dimple is visible at the top. This notch deepens in older fronds, and if a section is made through the somewhat flattened stipe, parallel with the flat surface and through the axis of the frond, a large apical cell is seen at the base of the sinus (*Pl. X.*, *Figs. 15*, *16*). This apical cell is an epidermal cell. It is in the shape of a truncated pyramid, with the truncated end to the top or pointing outward. The apical cell is two or three times as large as the other epidermal cells, and is otherwise markedly distinguished by great richness and granularity of contents, and by the absence of chromatophores. The adjacent cells share these characteristics to a less degree. They show a diminution in the granularity of the protoplasm, and color grains begin to appear in all but the latest cutoff.

The apical cell, as seen in vertical section, cuts off daughter cells in succession, a lateral, then a basal, and then a lateral

on the other side (see diagram, *Fig. 16*). The daughter cells quickly divide again and again, but more frequently in a lateral direction from the apical cell than downward. The cells in these lateral zones divide more rapidly in planes transverse to the axis of the lamina. In this way the zone of most rapid growth extends out laterally and upward from the apical cell and soon grows up ahead of the growing point. As a result there is the bifurcated lobe.

Differentiation into the long pith cells begins only three cut-offs below the apical cell. In the wings it does not begin so soon. The zone of cells in the wings retains its power of fission longer than the cells below the apical cell.

The cells of the epidermis and the cortical zone attain the characteristics of these tissues but a short distance from the apical cell.

The outer cortical cells throughout the plant are capable of dividing and seem to constitute a kind of cambium around the plant. This meristematic nature of the cortex is most highly developed in the lobes of the young lamina near the growing point. It is also well developed where conceptacles form and in the marginal parts of the holdfast.

The cuticular sheath that covers the whole plant is very thick over the delicate growing point, being about as thick as the length of the epidermal cells beneath it, no doubt serving as a protection.

It is customary to speak of the rows of cells in the plant as hyphæ. But when the origin of these cells is considered, that they are derived directly or indirectly from a single apical cell, the idea of their hyphal character seems a little incongruous.

On the development of the conceptacle. — As before noted the conceptacles show an intimate connection with the cortex. Sectional views prove the cortical origin and nature of these structures.

The first indication of the beginning of a conceptacle is seen to be the cutting off of a basal layer of cells from the lower end of a few adjacent epidermal cells (*Pl. V., Fig. 17*). These basal cells in turn divide periclinally and radially to form a little pad of meristematic cells beneath the epidermis, around which the cortical cell-rows are deflected. Directly over this mass of basal cutoffs, usually in the center, one or more epidermal cells begin to show signs of disintegration and collapse.

The walls of these cells stain more deeply than those of normal cells, the nuclei disappear and the chromatophores fuse together into a dark mass. The affected cells collapse gradually, beginning at the outer end. Often a little conical remnant of the shrunken cell may be seen on its basal cell. The walls and contents of the disintegrating cells change into a mucilaginous substance.

Thus far my observations agree with those made by F. O. Bower.[1] Bower states that the epidermal cell collapses, but that the basal cell persists, and that it sinks farther and farther into the cavity of the conceptacle, and that the lateral daughter cells of the central basal cell by their division form the lining wall of the cavity. He seeks to limit the disintegration of the epidermis at first to one cell and to make its basal cell the center of the whole process of the development of the conceptacle.

The serial sections made by me for the investigation of this matter do not show that the disintegration is thus confined to one single epidermal cell. Occasionally several will be equally far advanced in decay. Naturally one or the other of these may decay more quickly than the rest, producing thus a line of weakness and apparently a central axis about which the other decaying cells are grouped.

Again, it was not found that the basal cell or cells of the disintegrating epidermal cells persisted. On the contrary, they and several rows of cells below, perhaps five or six, share in this disintegration. It was frequently possible to make out the remains of the disintegrating cells in the mucilaginous mass to which they changed, and with which the cavity formed by their collapse was filled.

Neither did it appear that the basal cutoffs of the epidermal cells produced lateral daughter cells to line the cavity. It did appear that they divided chiefly periclinally and somewhat radially, forming five or six rows of meristematic cells, the outer rows disintegrating and forming the cavity; the deeper ones persisting and finally forming the inner wall of the conceptacle and giving rise to paraphases and the reproductive organs. Bower shows figures like *19*, *Pl. XI.*, in which the two cells, *b* and *c* on either side of the central basal cell *a*, might suggest that they were the lateral daughter cells of this basal cell. But

[1] Bower. Development of the Conceptacle in Fucaceæ. Qr. Jr. Mic. Sci. 36. 1880.

sections like *Fig. 21* are met with in which it is clearly seen that these lateral basal cells are not the daughter cells of the central basal cell *a*, but that they are the basal cutoffs of the epidermal cells above them. They are, therefore, coördinate with the basal cell *a*. The cells *e* and *f* are later cutoffs which the epidermal cells *g* and *h* succeeded in cutting off before becoming affected by decay. On account of less resistance from the cavity than on other sides these lateral basal cells grow usually in the shape shown in *Fig. 19*.

To summarize my conclusions on this point, the conceptacle originates by a few contiguous epidermal cells cutting off basal cells, *Fig. 17*, which are meristematic, dividing principally periclinally into half a dozen or more tiers of cells. Directly over this meristematic mass of cells, whether by the tension produced by the growth of the cells below, or otherwise, one or several epidermal cells begin to show signs of decomposition. The disintegration proceeds and the cells collapse (*Figs. 19* and *21*), and a cavity is begun. The disintegration spreads to neighboring epidermal cells and to the cells in the meristem below (*Figs. 21, 23* and *25*). By their decay the cavity is enlarged. The deeper and marginal cells in the meristematic mass do not disintegrate, but in the end make the inner wall of the conceptacle, and give rise to paraphases and reproductive organs (*Figs. 27, 28, 29*). The mucilaginous remains of the decayed cells for a time fill the cavity, or protrude from its mouth, or close the mouth as a stopper. The diagrams, *Figs. 18, 20, 22, 24, 26*, corresponding respectively to *Figs. 17, 19, 21, 23, 25*, illustrate how it is possible to explain the development of the conceptacle without using Bower's central, persisting, basal cell theory. It is not probable that the development of the conceptacle in *P. fastigiata* is different from that in the closely related plants which he describes. Since this work by Bower is the principal reference we have on the development of the conceptacle in the Fucaceæ, and is generally quoted, it would be profitable for others to repeat these investigations.

Finally the disintegration stops, a healthy surface layer of cells then lines the cavity and the dead and mucilaginous cells are cast off into the cavity. Meanwhile the unaffected epidermal cells continue to divide and form their basal cells which pass into the cortex. This new cortical growth stops abruptly at the conceptacle. In this way the cavity is deepened and a

neck is formed to the cavity, this neck being composed of epidermis-like cells. The original cortical rows are at first slightly deflected around the forming cavity, but later become deeply invaginated and thus aid in the deepening of the conceptacle. The cells of these layers become flattened and lenticular in shape, and are arranged in concentric layers, three to five deep, around the cavity thus forming a basket-like receptacle. The cells on the side toward the cavity are thin-walled and small, the outer cells are larger and have more intercellular jelly (*Pl. XI., Figs. 27–29*).

The cavity of the conceptacle is generally nearly spherical. Occasionally it is oval in shape with the longer axis in various directions. Where several conceptacles occur close together, there may be considerable distortion in their shapes.

The cortex over the conceptacle is slightly elevated by the growth of the conceptacle, but is gently curved again into the ostiole. The angle between the epidermis and the conceptacle is filled in with rather irregularly disposed cortex cells belonging to the deeper strata. The pith is sharply marked off from the flattened cortical cells around the conceptacles.

The mucilaginous remains of the disintegrated cells stay within the cavity for a considerable time, even till the reproductive organs form. Shreds and layers of this mucilage may also be found outside the conceptacle around its mouth. Frequently it closes the neck of the conceptacle like a stopper (*Fig. 27*). It seems to be finally partly absorbed and partly extruded by the paraphyses.

Bower thinks that the protrusion of the conceptacle into the pith is caused by the turgidity of the conceptable when filled and stoppered with the mucilaginous contents, the bulging being rather toward the softer and more yielding pith than toward the more rigid cortex, though even here it is noticeable. This explanation is insufficient, as it hardly seems possible that the conceptacle is closed tightly enough for the purpose, and especially since the greatest swelling of the conceptacle into the pith is in the later stages when the cavity has already begun to discharge or absorb the jelly and is no longer completely filled nor tightly closed. The principle of the arch might help to explain this protrusion of the conceptacle. As the cells in the wall of the conceptacle grow and multiply the arch which they form would create a distinct pressure on the surrounding tissue.

Paraphyses. — When the disintegration of the cells to form the conceptacular cavity is about finished, and while masses of mucilage still encumber the cavity, the first appearance of the paraphyses can be observed (*Pl. V., Fig. 27; Pl. XII., Fig. 38*). At this time the conceptacle is lined with one to three layers of thin-walled, ovally flattened cells, which are devoid of chromatophores or have only a few minute ones. The cells near the ostiole have more color bodies. These cells are filled with a granular protoplasm like the apical cell, though not so richly. The walls of these cells do not stain as deeply as the other cortical cells. The granularity referred to is evidently associated with activity in cell division.

Paraphyses arise as protuberances on the inner wall of some of the cells lining the conceptacle cavity. These protuberances may in young conceptacles project halfway across the cavity before they are cut off by a wall from their basal cells. The paraphyses appear at first in the lower half of the conceptacle. They very soon, even before they are cut off from their basal cell, begin to turn toward the ostiole.

As stated, the paraphyses in the main portion of the conceptacle arise as lateral buds from the cells in the wall of the conceptacle. The paraphyses at the upper end around the ostiole appear to form somewhat differently. They look as if they consisted of the unravelled or loosened cell rows of which the conceptacle wall is composed, and which crop out in the region near the top of the cavity (see *Fig. 29*).

As the paraphyses develop their end cells especially divide, though lower cells may do the same. The protoplasm remains in communication between cells. The protoplasm is slightly granular, nearly devoid of color bodies, except the end cells of the paraphyses about the ostiole. These are well provided with chromatophores, from which it would appear that their function is in part assimilative. Mature paraphyses consist, in the lower part of the conceptacle, of four or five cylindrical cells of almost uniform diameter. The end cell is tapering. The cells are about two or three times as long as wide. The paraphyses in the upper part of the conceptacle are more slender and their cells are shorter and more numerous, eight to ten.

The paraphyses are very numerous in a conceptacle. They are especially numerous and crowded at the top, though they are arranged here in regular, parallel order. In a few cases

paraphyses were observed projecting out of the ostiole, but not very much, only two or three cell lengths.

Reproductive organs.—The oögonia and the antheridia appear at about the same time. *Pelvetia fastigiata* has hermaphrodite conceptacles, and it is impossible to say that the oögonia or antheridia have special parts of the conceptacle on which to grow. Both may be found anywhere, except that the antheridia do not seem to develop as close to the ostiole as the oögonia sometimes do. Both organs arise in the same way as paraphyses, as buds from the cells that line the conceptacle.

Oögonium.—The oögonium may be recognized from the beginning by the fact that the cell which forms it from the first has darker contents than the rest of the cells in the conceptacle wall (*Pl. XII., Fig. 30*). The young oögonia also are darker. The contents of the oögonial mother cell are composed of a very granular protoplasm. The oögone arises as a swelling along the whole free surface of the mother cell. Paraphyses and antheridial hairs do not occupy so much of the free wall of the mother cell. In other words, they start as mere slender buds. After extending into the conceptacle a distance a little greater than the thickness of the mother cell, a dividing wall is laid down, thus forming the oögone and its basal cell (*Figs. 31* and *32*). This wall is evidently porous, as the protoplasm of both cells seems to communicate through it. The pedicel for some time retains the opacity of its contents but later becomes more like the other cells in the conceptacular wall.

The oögonial cell continues dark, increasing in opacity as it matures. This fact, together with the other fact that the fixing and preservation in formalin is not a good way to prepare these tissues for cytological study, in truth seems to make staining more difficult. For this reason it has been impossible to carry out the study of the development of the oöspheres in a satisfactory manner. It was found, however, that if the sections were bleached from fifteen to twenty minutes in chlorine gas, stained in hæmatoxylin for twenty-four hours, and washed in acid alcohol till the stain of the other tissues was nearly removed, then the nuclei of the oögones could be seen. Methyl violet and acid alcohol also brought out the nuclei. In younger and more transparent oögones the nuclei can be made out without bleaching. In this way the oögone was traced from the uninuclear to the four-nuclear stage (*Figs. 31–36*). Thuret states

that *Pelvetia* oögones divide into eight nuclei and that six of these are afterwards destroyed. Not more than four nuclei could be seen in the material studied.

The ripe oögone contains two eggs. A delicate transverse partition is laid down across the middle of the oögonial contents. Each egg is hemispherical or round-conical in shape. The lower one is often more pointed than the other. Nuclei could not be distinguished with definiteness.

The oögone increases rapidly in size, swelling to an oval or pear-shaped mass which surrounds itself with a thick gelatinous wall (*Figs. 36* and *37*). The oögonial wall is at first not different from that of the basal cell, but it soon thickens and becomes gelatinous so that it swells in water. This thickening continues till in the older oögones the swollen walls present the appearance shown in *Fig. 37*. Stratification is sometimes seen in this wall.

In dehydrating specimens this gelatinous wall splits into two layers, a thin outer layer, and a thicker, firmer, more densely staining one. These layers often remain in contact at different points and generally at the base where both layers are thin (*Fig. 36*). These two layers are the exochite and meso(endo)chite of Farmer and Williams.[1] From their account it would seem that this double-layered condition is the normal. The observations in this case, however, showed that the division of the oögone wall into two layers was unnatural. For nothing like it was observable in sections mounted in water or glycerine. The splitting is probably due to the tensions set up in the dehydration and the thicker mesochite layer is probably formed by the shrinking of the gelatinous middle substance upon the inner layer of the wall, therefore, being denser and appearing more intensely stained. A similar thing is noticeable everywhere in the dehydrated and stained pith.

Antheridia.—It is generally possible to find oögonia in any section made through a mature conceptacle. The antheridia are often much scarcer, and search has sometimes to be made through several sections before they are found. There is, however, probably no conceptacle entirely without them. On the other hand, some conceptacles contain a great abundance of antheridia crowded in bunches among the oögones and para-

[1] Contribution to Our Knowledge of the Fucaceæ: Life History and Cytology.

physes. The antheridia are more numerous in the lower half of the conceptacle.

It is usually stated that antheridia in different Fucaceæ develop on branching hairs. This also is the general rule here. It is not necessarily always the case through, for antheridia can frequently be found not on branching hairs, but on simple pedicel cells (*Pl. XII., Fig. 40*). The basal cells sometimes divide and later give rise to branches.

The antheridial hairs arise as papillæ or buds on the walls of the cells that line the conceptacle (*Fig. 39*). These papillæ are soon cut off by transverse walls. The outer cell elongates, divides and the lower of the two cells thus formed sends out a lateral bud near its upper end, which is later cut off by a partition. This process may be repeated several times along the main axis and the branches till a branching growth, not very dissected, is produced (*Figs. 39, 40, 41*).

The protoplasm of contiguous cells is in communication. Few minute chromatophores are found in these branching hairs. The granularity of the protoplasm is not very great as compared with that in the cells which develop the oögones.

Some of the end cells of the branching hairs increase in size, the nucleus divides into two, four, eight, etc., till about sixty-four nuclei are formed, so it is stated by authorities. In the material studied not so many could be counted, or estimated, only about forty. The nuclear division begins early, and different stages are all illustrated in the same section. The nuclei become somewhat smaller by successive division, this being especially noticeable in the earlier stages.

The antheridial cells are at first slender and somewhat pointed, but as the division within continues the cell becomes more and more rounded, usually oval in outline, slightly tapering at the top. The wall of the antheridium is at first thin. It soon thickens and becomes capable of swelling greatly (*Figs. 40* and *41*). The cell contents at first communicate with the basal cells, but later round up and draw away from the dividing wall. The spermatozoids stain quickly. They contain minute chromatophores. From one to six antheridia were observed on a single branching hair.

The plants studied for this paper were collected at the Minnesota Seaside Station by Miss Josephine E. Tilden, of the University of Minnesota. Thanks are due to her for them, and also for helpful suggestions given to the writer.

Methods: fixing and mounting fluids. — Material fixed and preserved in formalin was employed. This was washed in 30 per cent. alcohol, as fresh water alone caused injurious swelling of the laminæ. The material was then passed into higher per cents of alcohol to harden and dehydrate. The complete dehydrating seems to cause tensions in the body of the plant resulting in tearing apart of pith cells, the intercellular jelly giving way. But occasional very perfect pith sections may be thus obtained nevertheless, and by comparing with sections cut from 70 per cent. or 80 per cent. alcoholic material and mounted in water or glycerine the nearly natural appearance of these cells can be observed.

Most of the drawings were made from dehydrated material, and must therefore be somewhat unnaturally contracted. Where water or glycerine mounts were made and drawings from them, it is so indicated in the notes explanatory of the plates. The gelatinous walls swell greatly in glycerine (as compared with alcohol) but as the cross-sections of the lamina and stipe, for instance, have practically the same dimensions as the formalin material it may be assumed that the glycerine mounts give a truer picture of the tissues than do the balsam mounts.

Sectioning. — Most of the sections, especially the serial sections illustrating conceptacle development and the growing point, were made with a microtome from material imbedded in paraffine. After the work of hardening is once started this method is probably as rapid as any where imbedding is necessary. Some sectioning was done with a hand microtome, the 75 per cent. or 85 per cent. material being held in a pith clamp. Such sections were mounted generally in glycerine. These sections however showed a tendency to curl more than paraffine sections.

Staining. — A variety of stains were tried. Many of the ordinary wall stains proved entirely ineffectual. At length the following stains were selected as the best.

Fuchsine and methyl violet is perhaps the most generally useful. This mixture stains quickly and deeply. Washing cautiously in acid alcohol brings out different effects. Only a little washing leaves the gelatinous matrix slightly stained, the inner walls stain deeply, while the cell contents again take a slight coloring. Differentiation is brought out nicely, generally by more washing, in the conceptacular parts. The granular

inner cells of the conceptacle, the paraphyses, oögonia and antheridial hairs stain light red, the deeper cells of the conceptacle purplish, the pith cell walls dark red, while the color is all washed out of the matrix. Differentiation is also produced between different cortical layers, epidermis and cuticle and pith.

Methyl blue alone is a fairly good wall stain, but must be washed with care or it will all wash out. It also stains the chromatophores deeply. In this way the nuclei in the not too opaque oögonia may be located, they shining through as lighter areas in the dark mass of the oögone. Methyl violet is a quick stain. Over-stain and wash out as desired.

Bismarck brown was a very satisfactory stain for mapping out cell structure distinctly. It stains the inner wall of the cells (dark) brown, and the pith yellow. It is also useful in studying the structure of the conceptacle, the gelatinous sheath around the oögone being nicely brought out. It is a quick stain.

It may either be used dilute and allowed to stain longer, or more concentrated and then washed out till desired effect is obtained. Either way is good.

Hæmatoxylin dyes are better than carmine for nuclei. The most satisfactory results were obtained by bleaching the sections in chlorine gas for ten to fifteen minutes, then staining from one to two days in hæmatoxylin, then washing out till the walls and matrix were nearly clear, while the nuclei retained the stain longer. The chromatophores stain in hæmatoxylin and thorough washing is necessary to make the nuclei appear. Delafield's hæmatoxylin was found a good kind. The best effect was obtained by using a hæmatoxylin (brand unknown) that had been kept in solution at least ten years.

Iodine is very satisfactory for staining the protoplasm, and is very helpful in studying the pits between the cells, and in studying the contents of the conceptacular organs.

The staining was done on the slide. Rather concentrated dyes were employed. For alcoholic solutions of dyes 70 per cent. alcohol was used.

Description of Plates.

Plate VII.

Photograph of single plant of *Pelvetia fastigiata*. Shows holdfast, bifurcation of stipe and of laminæ. The warty appearance of some older laminæ is due to papillæ caused by conceptacles. Several laminæ have burst open through absorption of water, and show the conceptacles on the inner side of the cortex. About one half natural size.

Plate VIII.

Photograph showing bed of *Pelvetia fastigiata* on the rocks at Port Renfrew, exposed at ebb tide. This photograph was taken by C. J. Hibbard for the Botanical Department of the University of Minnesota.

Plate IX.

Anatomical detail: All drawings were made with the aid of camera lucida, diagrams excepted. All on this plate about × 250.

1. Shows part of the cross-section of stipe from epidermis to center of stipe.

2. Longitudinal section of stipe, showing cells with protoplasm, nuclei and chromatophores. The protoplasmic connection between cells is indicated. The cuticle covers the epidermis.

3. Cross-section of lamina. Shows the large amount of intercellular jelly in the pith region.

4. Longitudinal section of lamina, showing anastomosing pith cells. The space between them is filled with intercellular jelly.

5. Diagram of longitudinal and cross-section of stipe or lamina. Shows radially elongated epidermal cell. Beneath this are six or more rows of cortex cells and beyond these the pith. The cortex is shown arising as a basal cut-off of the epidermis. Previous cut-offs are shown in different stages of growth and division. Growth is principally in periclinal and longitudinal directions. The outer cells are more regularly rectangular, but become more rounded on the edges and corners toward the pith. The inner cortex rows finally become modified into long, cylindrical pith cells. The cells are separated farther by intercellular jelly as the pith is approached.

6. Vertical section through central part of holdfast. The lower part is shaded to show that the cells are dead, elsewhere also where such cells occur. The basal cells are flattened. The walls of the dead cells are gelatinous. The cells are shown with chromatophore masses to help indicate division. In the upper part the cells are elongated. Here the stipe begins.

7. Vertical section through periphery of holdfast, showing direction of cell rows. Also shows meristematic character of cells near edge. Disintegrating cells are shaded.

8. Cross-section through central part of holdfast.

9. Cross-section through holdfast nearer to the edge of disc.

10. Edge of holdfast, in cross-section, showing division of cells in this region.

11. Diagram to illustrate transverse and vertical dichotomy of the cells in the peripheral part of holdfast.

12. Diagrammatic view of cross-section of stipe or blade to illustrate protoplasmic communication in epidermal and cortical region. The chromatophores have been left out. Shows increase of intercellular jelly toward pith, crowding cells apart, except at the pits, showing formation of protuberances from adjoining cells.

13. Pith cells showing protoplasmic contents, nuclei and chromatophores. Shows end plates apparently permitting protoplasmic communication.

14. Shows lateral pits at anastomosing point of two pith cell rows.

Plate X.

Anatomical detail.

15. Growing point with apical cell dividing in two lateral and a basal plane, rapid multiplication of cells in the lateral regions; less rapid in the axial region. Rapid differentiation into pith in axial region; less rapid in the wings. Illustrates mode of bifurcation, × 375.

16. Same in diagram.

Plate XI.

Anatomical detail. Development of conceptacle, × 300.

17. Beginning of conceptacle. Shows basal cutoffs and disintegrating epidermal cells above them.

18. Same in diagram.

19. Later stage. Shows collapse of a central epidermal cell, remains of same appear as small cone on basal cutoff. Other epidermal cells are disintegrating, having however first succeeded in again cutting of a basal cell each, which have grown obliquely into the cavity formed by collapsed cell.

20. Diagram of same.

21. Later stage, more epidermal cells affected. Cavity filled with mucilage.

22. Diagram of same.

23. Later stage, basal cells disintegrating. Shows division going on in meristematic layer beneath.

24. Diagram of same.

25. Later stage. Shows cavity deepened, filled with mucilaginous remains of cells.

26. Diagram of the same.

27. Young conceptacle. Disintegration of cells has ceased. Their mucilaginous remains act as a stopper to the conceptacle. The neck is being formed by new layers of subepidermal cells. Paraphyses are beginning on the wall.

28. Later stage. Paraphyses and young oögonia have sprung from the cells lining the cavity. Chromatophores abundant near mouth, very few or small in lining cells. Cells in lining of cavity rich in protoplasm.

29. Nearly mature conceptacle with paraphyses, oögonia and antheridial branching hairs. Cells in wall of conceptacle have become flattened.

Plate XII.

Anatomical detail. Reproductive organs and paraphyses, × 250.

30. Beginning of oögone and paraphysis. Oögone cell densely granular. Paraphysis begins as a more slender protuberance of cell in conceptacular wall.

31. Later stage. Basal cells have been cut off by oögone and paraphysis.

32. Similar. An oögone anlage preparing to form pedicel cell. Paraphyses elongating and dividing.

33. Nucleus of young oögone dividing in two. Protoplasm still in communication with that of basal cell.

34. Later stage, another division of nuclei. The protoplasm of the oögone has been forcibly torn away from that of basal cell, probably in dehydrating process.

35. Oögone in four-nucleated stage.

36. Four-nucleated oögone showing thickening of wall and separation of wall into thin exochite and thick gelatinous mesoendochite. The two layers still adhere in places. Wall remains thin at basal pit.

37. Mature oögone with two eggs. Was mounted in glycerine which caused swelling of walls.

38. Young conceptacle showing origin of paraphases as protuberances from cells lining cavity of conceptacle.

39. Young branching hairs, showing mode of branching.

40. Bottom of nearly mature conceptacle, showing oögone, paraphyses and branching hairs with antheridia. Antheridial protoplasm is shown in different stages of division.

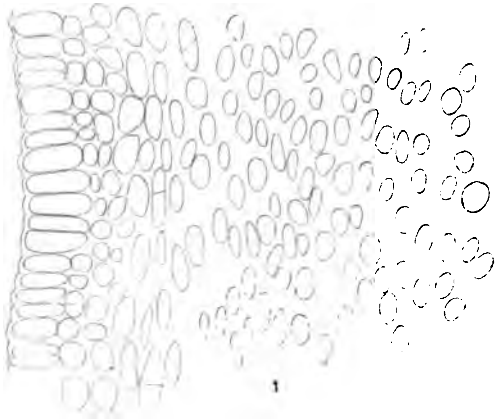
41. Single branching hair in glycerine. Antheridia with sperms and swollen walls.

PLATE VII.

HELIOTYPE CO., BOSTON.

PLATE VIII.

HELIOTYPE CO., BOSTON.



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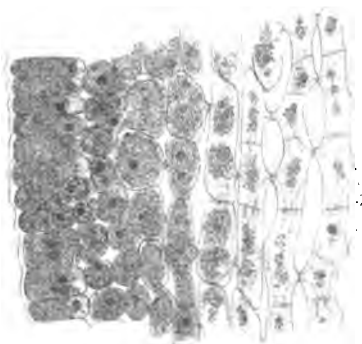

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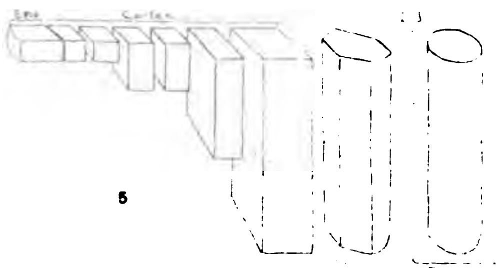

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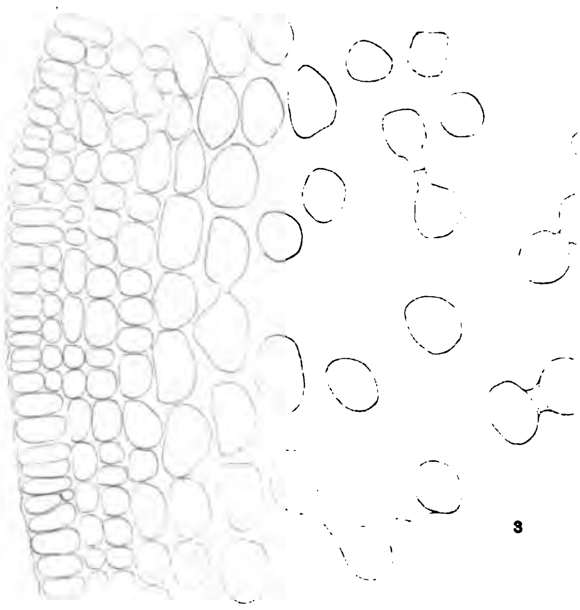

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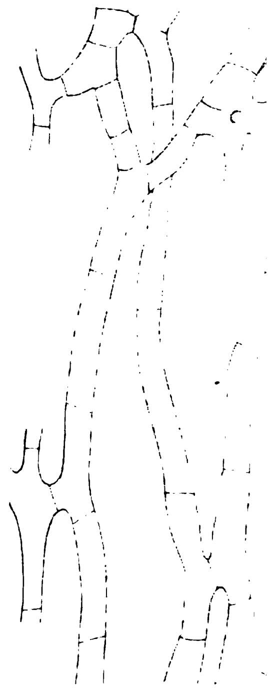

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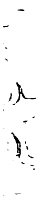

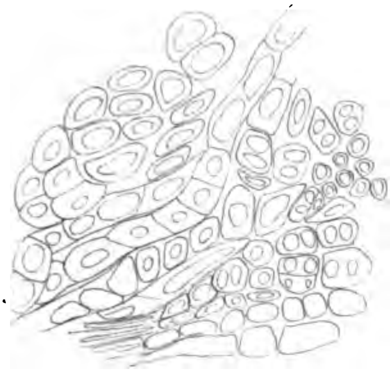

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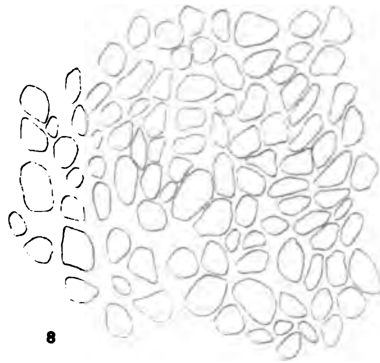

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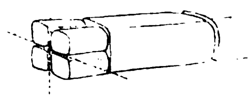

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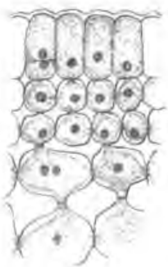

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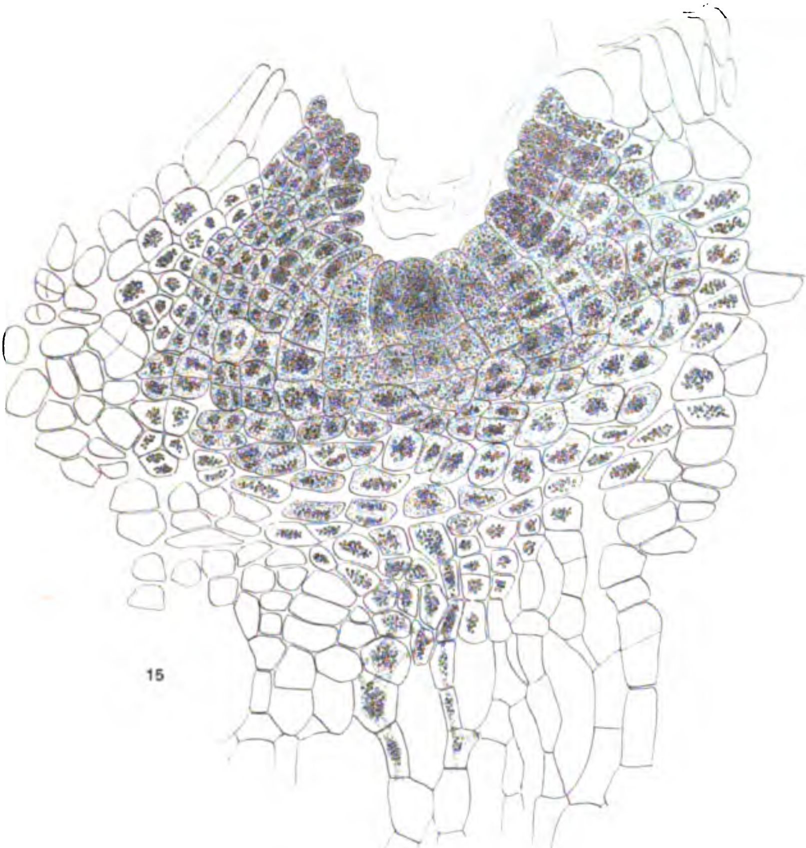
O., BOSTON.



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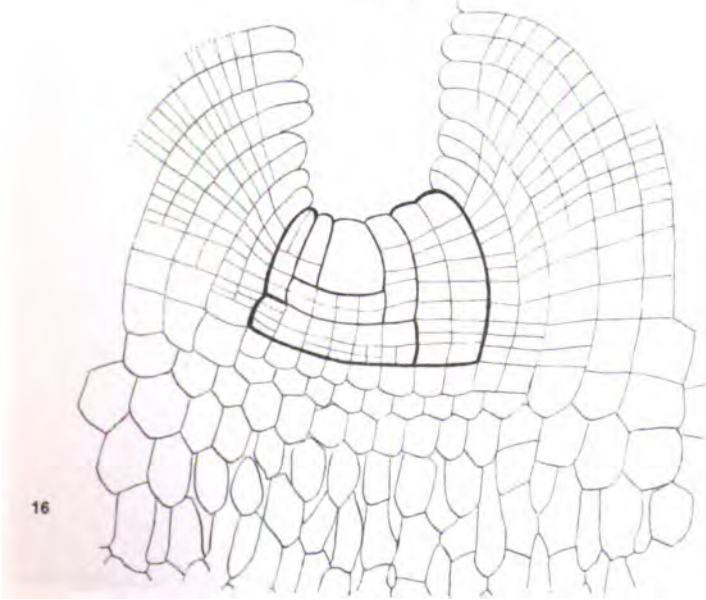

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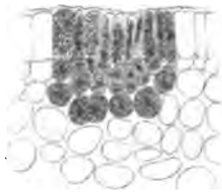
PLATE X.

HELIOTYPE CO., BOSTON.



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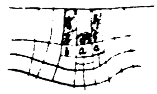

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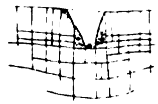

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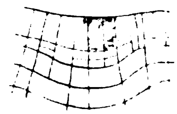

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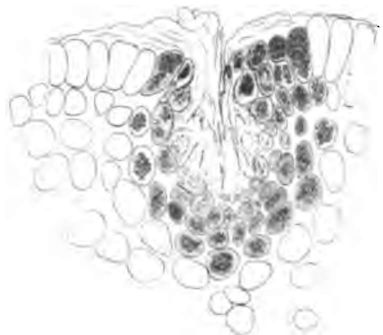

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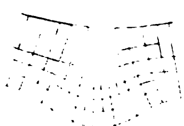

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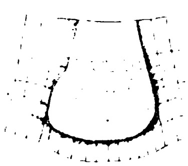

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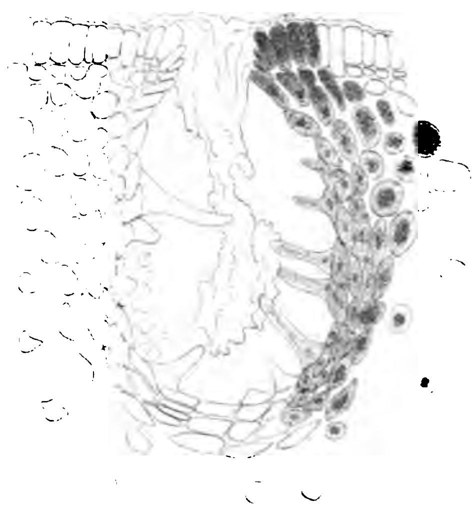

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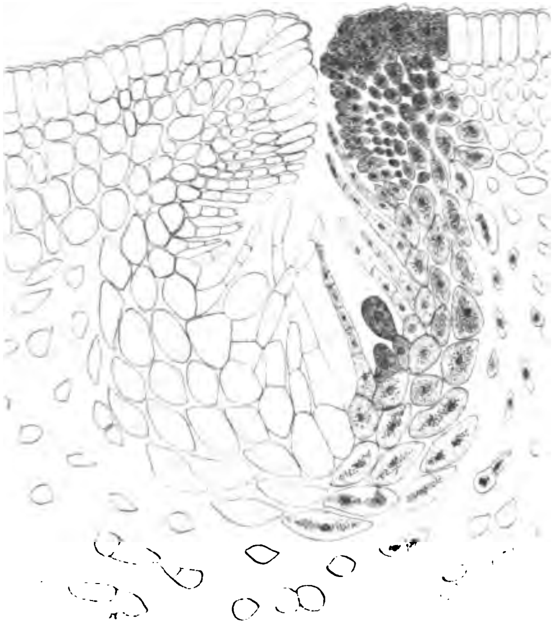

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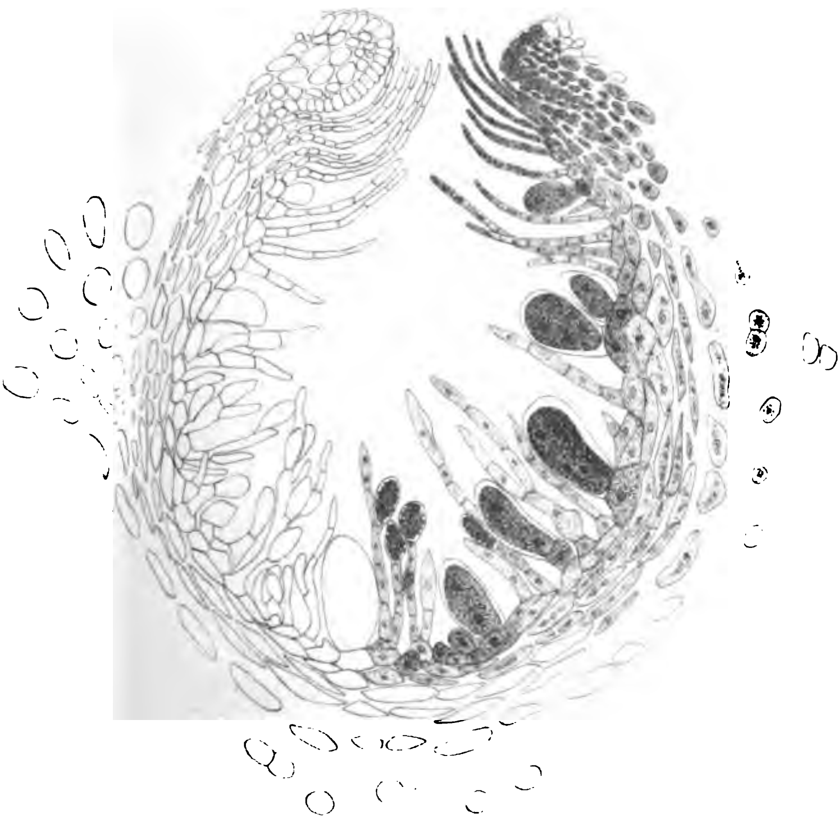

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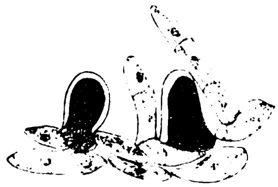

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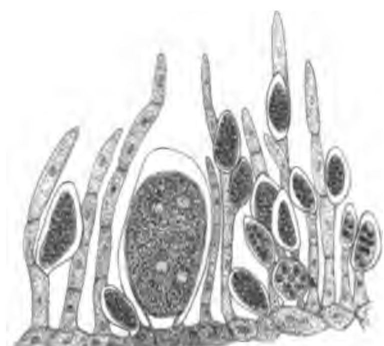

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PLATE XII.

HELIOTYPE CO., BOSTON.

IV. PETALONEMA ALATUM IN MINNESOTA.

Daisy S. Hone.

History.—This alga was discovered first in West Scotland by Captain Carmichael, about 1823–1828, and was first figured and described by Dr. Greville as an *Oscillatoria.* It has since been found in various places in Europe, both in the British Isles and on the Continent. In 1849 Harvey found it growing on dripping rocks under Biddle Stairs, Niagara Falls, in America. It was found by the writer near Minneapolis, Minnesota, in October, 1901.

Collection and preservation.—The Minnesota material was collected from the gravel bed of a quiet stream, the outlet of an old tank near the Government Dam works, Minneapolis, on October 12, 1901. It formed a dark chestnut brown stratum. A portion was preserved in a 5-per-cent. formaline solution and the remainder dried for herbarium specimens. The dried material when soaked regains its original form so that it is as good for study as the preserved. However, the formaline material was used in the work recorded in this paper.

Methods.—A small portion of the pickled material was washed in water and then mounted directly in glycerine jelly. If the jelly be raised above the melting point the threads collapse. All the drawings used in this paper were made from a single slide which has been thus preserved.

Staining in toto was tried with several fluids, but without valuable result. After washing the material in water for twenty-four hours it was treated with dilute hydrochloric acid for twenty-four hours and then various staining fluids tried. A dilute solution of Kleinenberg's hæmatoxylin stained the sheath a beautiful blue, leaving the trichome deep green. Aniline safranine stained the trichome red without affecting the sheath. Dahlia colored the trichome a deep blue and slightly affected the sheath. Fuchsin acid stained the whole red. Iodine turned the trichome brown.

Material was also washed with water for twenty-four hours and then passed through the alcohols before staining, but no advantage was gained. The material treated with hydrochloric acid differed only in that it showed a more distinct vacuolated condition, which in the younger active pseudocysts was very apparent. Many of these pseudocysts also showed a single very large granule, but this may also be seen in the normal condition. Nearly all the stained pseudocysts are constricted along the middle region.

OBSERVATIONS.

The dark brown color of the stratum is due to the color of the gelatinous sheaths in which the trichomes are imbedded.

Filaments.—The filaments are not attached, yet the gravel remained clinging to them when they were detached from the bottom of the stream, due no doubt to the gelatinous nature of the sheath. They seemed to lie horizontally and to be without any definite arrangement. They are in general more or less curved. Many of the filaments are without branches, but pseudobranches are not at all uncommon. Branching occurs either near a heterocyst or at a distance from it (see *Figs. 5* and *6*). In the first case there is but one branch, that is, the trichome being broken off at the heterocyst is thrust out as a single thread which soon secretes a new sheath about itself. In the latter condition both the broken ends of the trichome project, so that there are two branches or twin branches.

Sheath.—Harvey's description cannot be improved upon: "When placed under the microscope the filaments present the appearance of a cylindrical central column, containing annulated, olive-colored endochrome and a wide, wing-like border at each side of the column. This border or sheath is obliquely striate, the striæ running in an arch from the margin toward the center, where they become parallel and are then continued longitudinally downward along the medullary column till lost in the density. The margin of the wing is closely crenulate, and in age transversely striate at the crenatures as though jointed. Such is the apparent structure; the real structure seems to be that an annulated central filament is enclosed within a number of compressed, trumpet-mouthed gelatino-membranaceous tubular sheaths, one arising within the other and successively developed as the growth proceeds. These sheaths, thus concentrically arranged, are indicated by arching

longitudinal striæ, and the mouths of the younger sheaths, projecting slightly beyond those of the older, form the crenatures of the margin."

I find the central cylindrical column containing the trichome to be dense and often very thick near the heterocyst (*Fig. 4*), while near the apex of the filament it generally becomes thin and often scarcely traceable (*Fig. 3*). Thus it would seem to be a second sheath within the larger outer one, or it may be merely a very dense interior folding of the sheath proper, intensified near the heterocysts because of the greater rigidity of that portion. The internal striations of the sheath have a beautiful golden or dusky brown feathery appearance. Those farthest within being brown or golden present all shades of brown and yellow as they approach the periphery, where the sheath becomes colorless and transparent. A quite common condition is illustrated in *Fig. 5*, in which a dense old sheath, contracted for a limited distance, after branching expands into the usual form.

Trichome.—The trichome is normally of an olive-green color, cylindrical or somewhat moniliform, separated into distinct pseudocysts or apparently continuous. The apex is often gradually constricted with the tip enlarged. Very often this tip is rose-colored.

Pseudocysts.—The pseudocysts are exceedingly variable in size and shape, this depending upon their age. The younger active pseudocysts are globose in shape, 9–15 mic. wide. When ready to divide they lengthen until they are twice as long as wide (*Fig. 7*). The contents are coarsely granulate. Often a single large granule is seen in each pseudocyst (*Fig. 3*). The older pseudocysts are often rectangular in outline (*Fig. 4, a*). These are sometimes 20 mic. long and 6 mic. wide. They are more finely granular and densely packed. The apical pseudocyst and often three or four below are coarsely granulate and are of a deep pink or red color.

Heterocysts.—The heterocysts are interstitial and sometimes occur at the base of a branch (*Fig. 5*). They are solitary. In shape they are somewhat globose or oblong. In stained material the watery contents take a beautiful color. In size they are slightly larger than a normal pseudocyst.

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Explanation of Plate XIII.

Figure 1. Apex of a filament showing striæ of the sheath, or the "mouths" of the younger sheaths projecting from the older ones. *a*, trichome, × 154.

2. Same view as Fig. 1, but with different focus showing the concentrically arranged striæ with the central portion. *a*, trichome, × 154.

3. Apex of a filament with well-developed trichome about to slip out from end of sheath, × 154.

4. A portion of a normal filament showing heterocysts and hormogone with a very dense central folding of the sheath about the trichome, × 154.

5. A portion of an older filament showing a branch given off at the heterocyst, × 154.

6. A portion of a filament showing four branches not in the neighborhood of a heterocyst, × 154.

7. A trichome showing active division removed from sheath, × 154.

8, 9. Stained trichomes removed from sheath. 8. Mature pseudocysts. 9. Young pseudocysts, × 154.

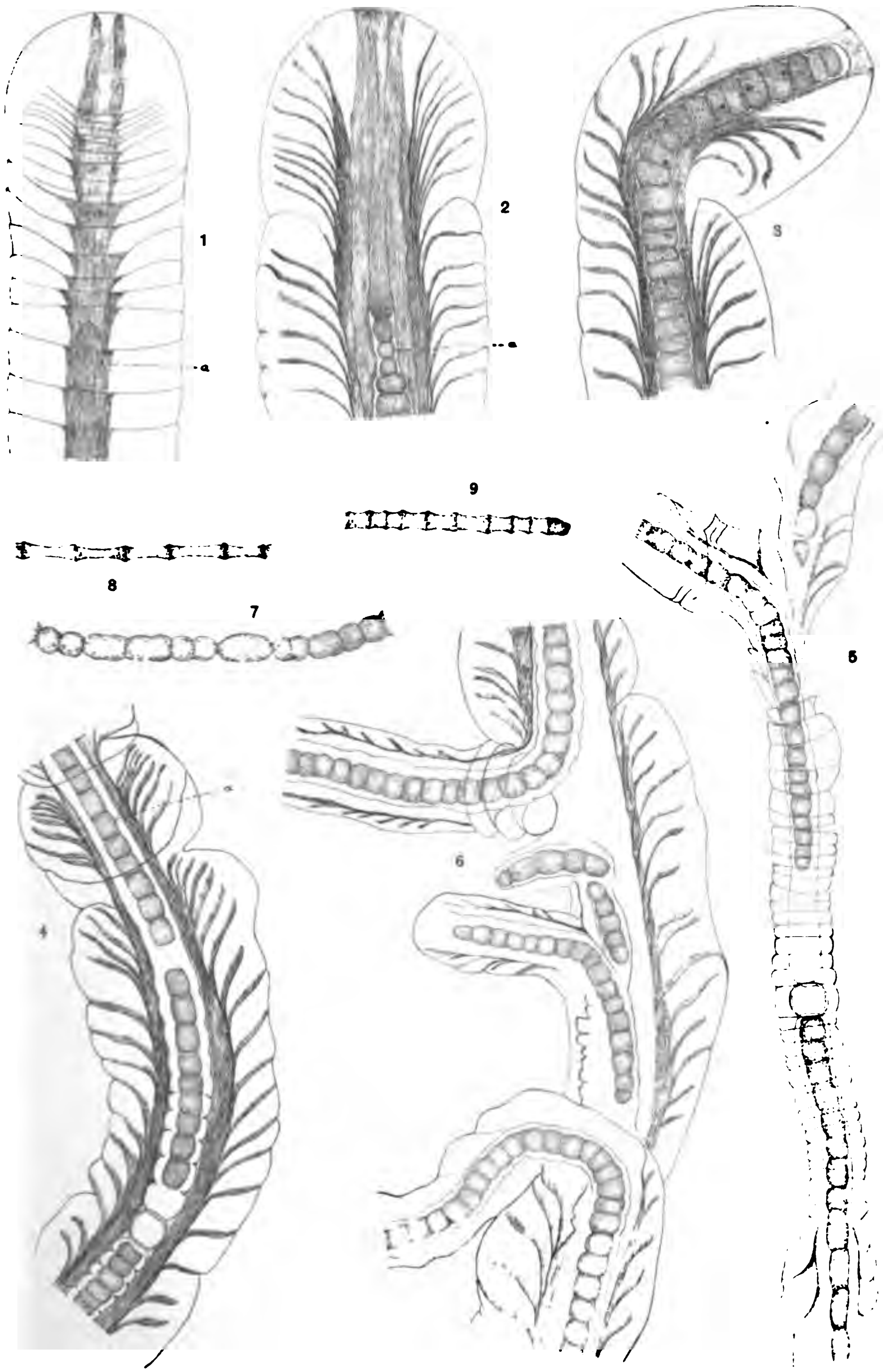

PLATE XIII.

HELIOTYPE CO., BOSTON.

V. OBSERVATIONS UPON SOME ALGÆ WHICH CAUSE "WATER BLOOM."

N. P. B. Nelson.

An endeavor has been made to collect some of the more important known facts concerning "water bloom" as it occurs in Minnesota and neighboring states. It seems quite certain that at least some of the algæ causing this appearance in water supplies are of considerable sanitary importance. It is the object of this paper to give, not a complete and scientific treatise, but a general and practical description of the phenomenon and its causes and effects so far as known. Up to this time there is no record of its occurrence to any great extent in the rivers or lakes supplying drinking water to the inhabitants of cities and towns of the state, but in several instances it has apparently caused the death of cattle and other animals.

Occasionally persons interested in the matter have sent specimens to the Department of Botany at the university, and it would be well if this were more generally done. Such collections with notes accompanying them are of the greatest aid in acquiring a more general and complete knowledge of this kind of vegetation. A small amount of the material, immediately upon being taken out of the water, should be placed in a vial containing a 5-per-cent. solution of formaline. It can then be packed in a small box with cotton and sent at any convenient time. Such a solution of formaline can be purchased for a few cents at any drug store.

History.—The first published record of the occurrence of this "water bloom" in the state of Minnesota was that of J. C. Arthur (1) in 1883. "A very fatal disease among cattle and hogs in Waterville, Le Sueur county," was reported on the 8th of July, 1882. Professor Arthur visited the locality and describes the condition as follows: "On June 28, 1882, after two or three days of pleasant weather, the wind gathered a thick scum of algæ in the little bay (on the north shore of Lake

Tetonka near the house of Mr. L. H. Bullis). Four calves confined in a pasture near the house, with access to no water but that of the lake were seen at noon apparently well, and at 2 P. M. were dead. On July 5, a number of cattle came down the public road to the lake shore, that partly belonged to Mr. Bullis and partly to neighbors. They were noticed between 8 and 9 A.M. and within an hour afterward three were dead, and before noon three more. . . . The two young cattle were examined shortly after death by Dr. E. B. Case and Dr. J. G. Bemis, resident physicians. Nothing seemed to be abnormal except the stomach, which appeared to have been affected by the algæ swallowed by the cattle. . . . The cattle did not appear to suffer pain, but lay down as if enervated and soon expired." The total number of animals thought to have died from the same cause at this time included about twenty head of stock, horses, cattle and hogs.

The scum when examined was found to consist of minute balls each made up of a dense colorless jelly in which was embedded a great number of dark-green, whip-like filaments, lying side by side and radiating from a center. The larger ends were at the center and the attenuated ends extended beyond the jelly. Each filament was made up of a row of pseudocysts enclosed in a sheath and at the basal or inner end was attached a spherical heterocyst. When decaying in masses the plant caused a nauseating odor. The plant was determined by Dr. Farlow to be *Rivularia fluitans* Cohn.

Several weeks later Professor Arthur revisited Lake Tetonka. *Rivularia fluitans* had disappeared, but in its place was another scum-forming alga, intensely green in color, diffused throughout the water and collected by the wind into a scum two or more inches thick along the shore. Under the microscope it appeared to consist of irregular colonies of minute plants. Each colony was a mass of thin, colorless jelly containing many separate oblong blue-geen cells placed some distance apart. This plant is known as *Cœlosphærium kuetzingianum* Naeg. and is not considered injurious. A small quantity of *Anabæna circinalis* (Kuetz.) Rabenh. was also found associated with this plant. Still another " water bloom " species found at this same time and almost as abundant as the *Cœlosphærium* was an alga named *Aphanizomenon flos-aquæ* (Linn.) Ralfs. It consisted of little bundles of thin, delicate filaments.

The next reference to the subject was made in 1889 by Dr. Wm. Trelease in an article, "The Working of the Madison lakes, Wisconsin." He observed that every season a greenish-yellow scum occurred in greater or less quantity on the lakes during the hot part of the summer, after the weather had been calm for a number of days in succession. When but little of the scum-forming substance was present it appeared as fine granules suspended in the water. Under the influence of a gentle breeze, continuing in one direction for some time, these particles were carried to the shore, accumulating to form a slimy scum which quickly putrefied, giving off a disagreeable odor. During the process the color of the mass changed to a decided blue-green, which stained the pebbles, sticks, etc., over which it was smeared. This material consisted mainly of *Clathrocystis aëruginosa* (Kuetz.) Henfr. At different times collections taken from the lakes proved to be, besides the *Clathrocystis*, *Anabæna flos-aquæ* (Lyngb.) Bréb., *A. mendotæ* and *A. circinalis* (Kuetz.) Rabenh.

In August, 1897, Miss Elizabeth H. Foss, a student in the Botanical Department, collected *Glœotrichia pisum*, floating in large quantity on the surface of Lake Minnewaska, Glenwood, Minnesota, and on October 28 of the same year, Miss M. G. Fanning and Mr. H. B. Humphrey found *Anabæna flos-aquæ* in abundance in Cedar lake, Hennepin county, Minnesota.

In November, 1899, Miss M. G. Fanning, then a student in the Botanical Department, began making a study of the St. Paul water supply. Of the "water bloom"-forming algæ she found specimens of *Anabæna flos-aquæ* (Lyngb.) Bréb., and *Cœlosphærium kuetzingianum* Naeg.

In August, 1900, Professor Caswell A. Ballard, of Moorhead Normal School, Moorhead, Minnesota, made a collection of a "water bloom" form from one of the shallow lakes in the depressions of the Fergus Falls moraine. A sample of the material was sent to this department and it was determined to be *Aphanizomenon flos-aquæ* (Linn.) Ralfs. (*Pl. XIV., Fig. 1*).

Professor Ballard's attention was first called to this locality by the report that several cattle in a pasture adjoining the shore of the lake had died, apparently from poisoning. It was observed that the lake was in a peculiar condition, the water colored by a blue-green scum. A zone from twenty to twenty-

five feet wide, from the shore out into the lake, was almost thickened by the presence of a great number of colonies or bundles of this plant. This scum being suspected as the source of danger, a temporary fence was put up to prevent the cattle from drinking out of the lake. After that, none of the cattle died or showed symptoms of being poisoned. In a letter describing the circumstances, Professor Ballard states that he is convinced that the death of the cattle was due to the drinking of the lake water, either because of the poisonous characters of the algæ, or what seems more likely, because of the stagnant condition of the water which made the growth of the algæ possible.

On October 13, 1901, the writer collected some "water bloom" on the shores of Lake Minnetonka at Spring Park. The water here did not seem to be very deep for some distance from the shore. Neither was there a clean sandy bottom in the vicinity. Bulrushes grew abundantly in places and there were present some smaller water plants. The water of the lake was quite fresh and clear.

The algal scum was gathered at a few places along the shore by a gentle land-ward breeze. It had a pale bluish-green color resembling a mixed paint of that color. Microscopic examination showed the scum to be made up of two species of *Anabæna*, *A. flos-aquæ* (Lyngb.) Bréb. (*Pl. XIV., Fig. 3*) and *A. circinalis* (Kuetz.) Rabenh. (*Pl. XIV., Fig. 2*).

On October 24 another collection was made at the same spot. The scum was about the same in quantity, but was of a grayish-brown color, slightly tinged with blue-green. It was more slimy to the touch. It had an odor similar to mouldy grass or hay. Under the microscope it was seen that this difference was probably due to the presence of a much larger number of gonidia or reproductive bodies than had been found in the previous collection.

To the naked eye this scum appeared to be simply a shapeless mass, but examined with the microscope it was found to consist of innumerable filaments, resembling strings of beads. Each of these filaments or trichomes was composed of a number of somewhat spherical pseudocysts, almost uniform in size and shape. Each pseudocyst was filled with a dense, finely granular protoplasm. At intervals in the trichome were seen heterocysts, larger than the pseudocysts, with a more distinct wall and

thin watery contents. The gonidia were still larger, were surrounded by a thick wall and contained numerous granules of different sizes. When floating naturally in the water, each trichome of *Anabæna circinalis* coils itself into a loose spiral—hence its name. The trichome of *A. flos-aquæ*, on the other hand, is somewhat curved but not in a definite way.

These plants in moderate quantities are not supposed to be dangerous, but when they are present in immense numbers in stagnant water they are likely to have an injurious effect.

In 1897 Messrs. D. D. Jackson, Assistant Biologist, and J. W. Ellms, Assistant Chemist of the Massachusetts State Board of Health, made a series of chemical experiments on living plants of *Anabæna circinalis* collected from Ludlow Reservoir, at Springfield. "It is commonly believed by those who have not investigated the subject, that disagreeable odors and tastes in drinking waters are due to the decomposition of organic matter, and are either dangerous or indicative of danger to the public health. Biological investigations already published have sufficed to show that this is not always the case."

The plant under investigation proved to contain an essential oil giving the order of mouldy grass which is characteristic of the genus.

A chemical analysis was also made of the same plant in a state of decay and showed that "the odor of decomposing *Anabæna* is evidently not due, to any extent, to the production of hydrogen sulphide, but to the partial breaking down of highly organized compounds of sulphur and phosphorus. The odor is undoubtedly more offensive on account of the high per cent. of nitrogen present. It is true of the whole organic world that those products which give the most offensive odors of decay are partially decomposed, highly nitrogenous compounds, containing sulphur or phosphorus."

The investigators concluded that the usual cause for disagreeable odors and tastes occurring in potable water is found in the presence of large numbers of certain microscopical organisms which secrete compounds of the nature of essential oils. When the organisms are living these tastes and oders are as harmless as those of fresh vegetables or fish. When decaying, the plant produces the "pig-pen" odor (characteristic of blue-green algæ, Cyanophyceæ) due to the decay of highly nitrogenous organic matter in which partially decomposed sulphur and phosphorus

compounds play the leading part. The sanitary significance of this matter is yet to be determined, but so far analysis indicates that, in large quantities, the effect on general health would be unfavorable.

Summary. — Up to the present time there have been found, in or near the state of Minnesota, seven kinds of blue-green algæ which form "water bloom." They are:

Glœotrichia pisum (Ag.) Thuret. (*Rivularia fluitans* Cohn.)
Cœlosphærium kuetzingianum Naeg.
Aphanizomenon flos-aquæ (Linn.) Ralfs.
Clathrocystis aëruginosa (Kuetz.) Henfr.
Anabæna circinalis (Kuetz.) Rabenh.
Anabæna flos-aquæ (Lyngb.) Bréb.
Anabæna mendotæ (?)

In several instances it has been almost conclusively proved that the presence of one or more of these species in drinking water used by stock has caused fatal results.

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Explanation of Plate XIV. (in Part).

Figure 1. A "bundle" of trichomes of *Aphanizomenon flos-aquæ.* Drawn from Professor Ballard's collection, × 700.

2. *Anabæna circinalis.* *a*, pseudocysts; *b*, gonidium; *c*, heterocyst, × 193.

3. *Anabæna flos-aquæ.* *a*, pseudocyst; *b*, gonidium; *c*, heterocyst, × 193.

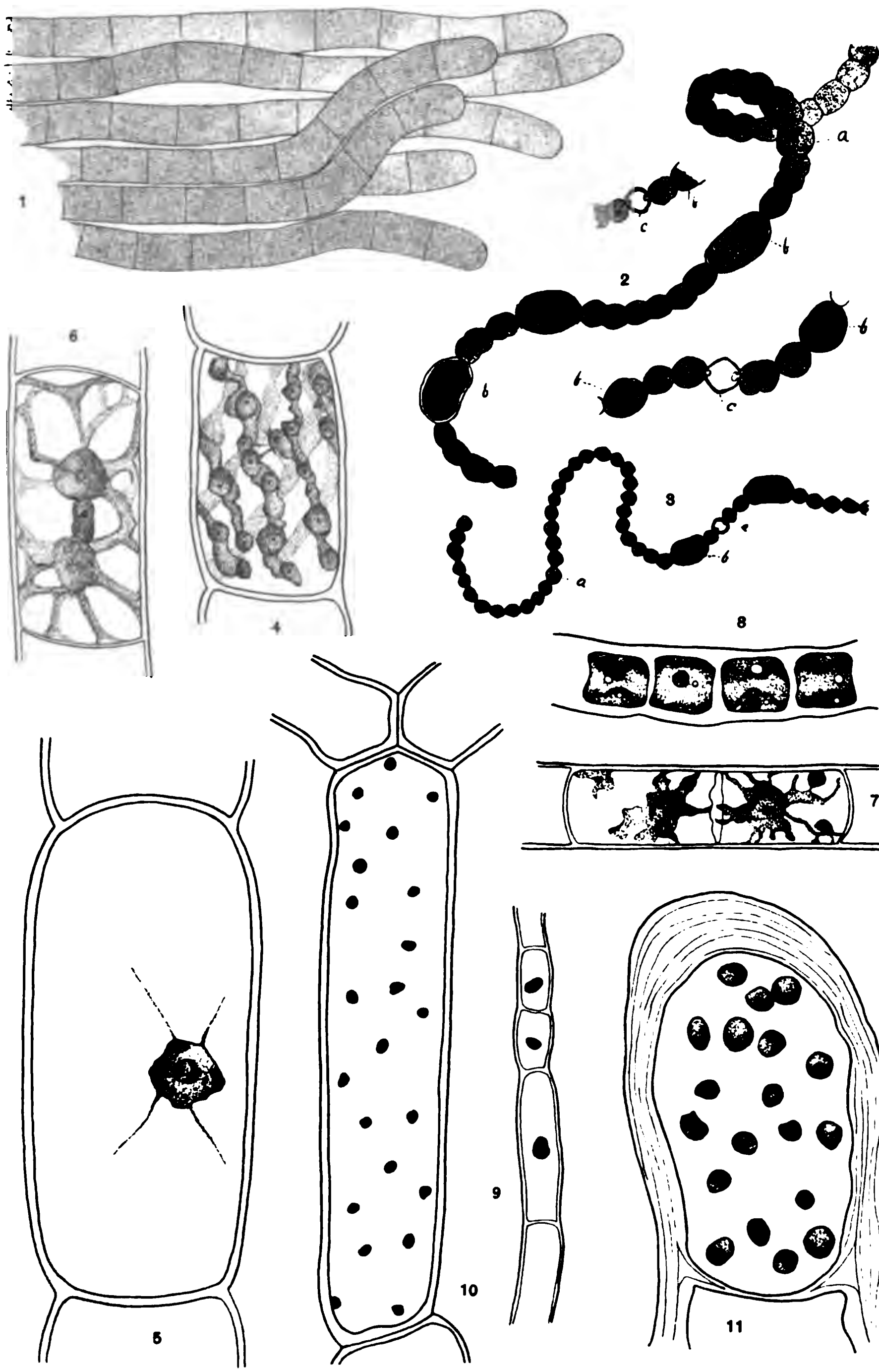

PLATE XIV.

HELIOTYPE CO., BOSTON.

VI. SOME OBSERVATIONS ON THE STAINING OF THE NUCLEI OF FRESH-WATER ALGÆ.

CATHERINE HILLESHEIM.

The material studied comprised several species of the commoner green algæ collected in the stone quarries along the bank of the Mississippi river near the university.

Staining.—The only fixing agents tried were chromic and picric acids. Various stains were used, such as hæmatoxylin, fuchsin, anilin safranin, gentian violet, borax and ammonia carmine. Staining living cells with dahlia was unsuccessful. After the material was stained and thoroughly washed, first in water and then in the alcohols, it was mounted in glycerine jelly or in formaline. The best results were obtained from the following method:

Chromic acid,	24 hours,
Water,	24 "
Alcohol, 10 per cent.,	4 "
Alcohol, 30 per cent.,	4 "
Alcohol, 50 per cent.,	4 "
Borax and ammonia carmine (one half of each),	4 days.
Glycerine and water (5 per cent. solution),	5 minutes.

The slide and cover-glass were then warmed and a small drop of glycerine jelly placed in the center of the slide. When this was melted the stained material was placed in it, the cover-glass laid on and the whole put away to dry. When mounted in formaline the preparation is ringed with Canada balsam to make it air-tight.

CELL STAINING.

Spyrogyra species.—The nucleus readily took on nearly all of the stains mentioned. It was stained pink by the ammonia-borax, carmine, fuchsin and aniline safranin. Hæmatoxylin stained it blue. The nucleus was situated near the center of the cell. It was much varied in shape in different species.

Thus, some were polyhedral, some oval, some spherical and some irregular in form. It also varied in size. The nucleolus stained much more deeply than the nucleus and was spherical in shape. Radiating in all directions from the nucleus are the lighter staining strands of protoplasm which, terminating in the pyrenoids of the chlorophyll bands, suspend the nucleus in the cell.

Zygnema species.— A mixture of ammonia and borax carmine gave the best results in staining in this form. Various stages in nuclear division were clearly brought out. *Pl. XIV., Fig.* 7, shows two daughter nuclei just after the formation of the cell plate. The nucleus is an elongated, oblong, bean-shaped body situated between the two chloroplastids. The nucleolus is generally situated in one end of the nucleus and is spherical in shape. Dahlia was tried but it stained all the contents of the cell without bringing out the nucleus.

Hormiscia zonata (Web. and Mohr) Aresch. — The method of staining was the same as above. The nuclei are somewhat spherical in shape, and occupy different positions in different cells. They lie within the chloroplastid, either at the center or near the wall.

Microspora species. —In addition to the first method, double staining was tried, the material being first stained with anilin safranin and then with gentian violet. This proved to be no more satisfactory than the first method. Stained with hæmatoxylin the nucleolus was brought out much more clearly than in either of the other ways. The method used is as follows:

Chromic acid,	33 hours.
Water,	22 "
Hæmatoxylin,	4 "

The material was then washed in water acidulated with HCl, then placed in a solution of glycerine, and mounted in glycerine jelly. The nucleus in *Microspora* is irregularly spherical or oblong in shape. It usually occupies the center of the cell.

Cœnocyte Staining.

Hydrodictyon reticulatum (Linn.) Lagerh.— The stain used was a mixture of ammonia and borax carmine. The nuclei do not seem to be distributed uniformly throughout the cœnocyte, but most of them occupy a layer or cylinder just within the cell

wall with a very few scattered about in the center. The nuclei are extremely numerous, as many as forty-six being counted in a very young cœnocyte, while in the mature cœnocytes there were many hundred.

Cladophora species.— Both the borax and the ammonia carmine stains were taken very readily by the nuclei of these plants. The nuclei, however, were brought out more clearly when hæmatoxylin was used. In a cœnocyte of one species thirty-eight nuclei were counted. In another species only six could be made out. The nuclei were mostly spherical in shape.

Summary.— The best fixing agent for the algæ studied was chromic acid. The most successful stain was a mixture of borax and ammonia carmine.

Explanation of Plate XIV. (in Part).

All the drawings were made with the camera lucida.

Figure 4. Cell of *Spirogyra.* Length of cell 100 mic., width of cell 50 mic. Diameter of nucleus, 12 mic., × 193.

5. Cell of *Spirogyra.* Shows relative size of nucleus and cell, × 450.

6. Cell of *Zygnema.* Nucleus in resting condition. Diameter of cell 37 mic., length 62 mic. Diameter of nucleus 7 mic., length of nucleus 12 mic., × 450.

7. Cell of *Zygnema.* Daughter nuclei, just after division is complete, × 193.

8. *Hormiscia zonata* (Web. and Mohr.) Aresch. Diameter of cell 20 mic., length 25 mic. Nucleus 5 mic. in diameter, × 450.

9. *Microspora* sp. Diameter of cell 10 mic., length 45 mic. Diameter of nucleus 5 mic., × 450.

10. *Hydrodictyon reticulatum* (Linn.) Lagerh. Diameter of cœnocyte 11 mic., length 66 mic. Diameter of nuclei 1 mic., × 193.

11. *Cladophora* species. Diameter of cœnocyte 63 mic., length 150 mic. Diameter of nucleus 7 mic., × 450.

VII. OBSERVATIONS ON DICTYOSPHÆRIA.

CAROLINE M. CROSBY.

NOMENCLATURE AND CLASSIFICATION.

The genus *Dictyosphæria* was founded by Decaisne, *Valonia favulosa* Ag. being chosen as the type. In further investigations by Harvey, Agardh, Kützing and Murray, this systematic position has been accepted by all, near *Valonia* and *Anadyomene*.

The present investigations have been confined to the single species *Dictyosphæria favulosa*, and to material collected in the Hawaiian Islands during the summer of 1900.

These notes will not attempt to discuss the classification which has been so firmly established, but will merely add some details of structure not noticed at length by Murray, and some possible explanations of certain disputed points.

COLLECTION AND PRESERVATION OF MATERIAL.

The material was collected in the following portions of the Hawaiian Islands, May–August, 1900:

1. Kapaa, Island of Kauai, most northern point.
2. Waianae, Island of Oahu, most southern point.

In all cases the material was collected at or near low tide, in shallow water.

The material used was preserved—

1. In 70 per cent. alcohol solution.
2. In 4 per cent. formaline solution.

Investigations were made chiefly on formaline material.

METHODS OF PREPARATION.

1. The material prepared with alcohol was allowed to stand twenty minutes or so in gum-arabic solution and then transferred to gum-arabic solution on the freezing chamber. As this medium necessitated transference to glycerine jelly as a mounting medium, the tissue proved too delicate for successful study.

2. Treated most satisfactorily as follows: Formaline material first washed in a fresh 4 per cent. formaline solution was put on freezing chamber in 4 per cent. formaline solution, and transferred directly into permanent mounting medium of 4 per cent. formaline.

The thallus, after repeated attempts with xylol and cedar oil as clearing media, proved too loosely constructed to cut by microtome. The Osterhout freezing method was used with the best results. Sections were cut 15 to 45 μ thick, the first proving best for detailed structure, the second for general outlines of thallus and cells. Hand sectioning proved of value only in a general way.

The staining of *Dictyosphæria*, en masse or in section, proved a difficult matter. The majority of the stains used had little or no value. The loose structure of the thallus could not endure hardening due to alcohol stains—therefore, water stains were used in nearly all cases. Owing to the nature of cell wall and mucilaginous contents the alcohol material was not more satisfactory than the formaline. The following stains gave poor results:

1. Methyl green (saturate solution in H_2O).
2. Fuchsin (saturate solution in 50 per cent. Al).
3. Bismarck brown (saturate solution in H_2O).
4. Borax carmine (almost saturate solution in H_2O).
5. Ammonia carmine (almost saturate solution in H_2O).

Aniline water-safranine (*saturate solution* in H_2O) for four minutes' time proved the most satisfactory stain, showing clearly structure of cell wall, needles, haptera, staining the mucilaginous cell contents a yellow-brown.

Sulphuric Acid (very dilute). Twenty-five minutes' time differentiated clearly starch grains of pyrenoid, a dark brown.

Nuclear Stains (alcohol material).

Delafield's Hæmatoxylin five minutes to twenty hours' time stained the walls a bright purple, but only stained cell contents a muddy brown.

Gentian Violet (concentrated solution H_2O), one to three seconds' time. Differentiated pyrenoid centers clearly, but proved too strong for all other structures.

Acid Fuchsin (saturate solution in H_2O), three hours' time, proved the best nuclear stain.

Mounting Media.

1. Glycerine jelly necessitated a second change from gum-arabic.
2. Pure glycerine proved too strong — drew out the stain and clouded when heated.
3. Formaline proved best.

Habitat.—Dictyosphæria favulosa occurs in all tropical seas, *i. e.*, Hawaiian Islands, Grenada, St. Thomas, Barbadoes, Ceylon, Mauritius, Red Sea and Philippine Islands.

In all cases it was found firmly attached by rhizoids to flattened coral reefs, as smaller, more rounded plants, or as larger somewhat appressed areas. In shallow water at low tide it grows attached to outer surface of reef or sides of hole in same. It is often mixed with or covered by other algæ.

Gross Anatomy.

A typical older thallus consists of an irregular, flattened, hollow hemisphere, with a single layer of large closely appressed, hexagonal cells, enclosing a hollow center; attached to substratum by central rhizoids on lower surface (*Fig. 1*). The thallus, in early stages somewhat bag-like, later flattens and becomes irregular in shape.

Owing to the plasticity of such an undifferentiated thallus, the size and shape of both surfaces are adapted to the position; expanded if attached to a flat surface; more bag-like in form with wedge-shaped base, if placed between two surfaces. Later the flattening of the upper and lower surfaces, and the irregularity of the upper surface arise as follows:

In younger solid plants the cells are of equal size. Soon those in the center enlarge and through the growth of outer cells become torn and disorganized (*Pl. XV., Fig. 4*). The hollow thus formed enlarges by the same process. The thallus lacks cohesion, gained by interlacing branches in *Struvea*, and is bound together by a membrane; this now splits in all directions causing the thallus to rupture. The membrane, mentioned by Harvey, Kützing and Murray, as extending over the plant body in younger stages, was not found.

The cells divide continuously and replace the torn tissue by a single-celled layer. The resultant form is irregular, expanded, with hollow center, enclosed by upper and lower surface layers, often filled with water (*Pl. XV., Fig. 2*). The outer surface of the cells is tough and membrane-like.

The thallus proved of interest. Murray considers it an aggregate of cells loosely bound by tenacula, comparable to the structure of *Struvea*. Dr. Schmidtz, of Greifswald, considers it an irregularly branched system, equivalent to a congenital branched *Cladophora*, or a collection of *Valonia*-like cells. Wille, in Engler and Prantl, compares it to a "thickly branched system" sent off from a single layer of cells, which coalesce to form the typical layer.

The writer would compare the plant body to a primitive, irregular, sessile, branched system, homologous to the elongated branched system of *Struvea*. Each cell may be considered a sessile detached branch, which coheres by haptera, not by incrustation.

The thallus is of a higher type than *Valonia*, but suggests it in size and structure of cells, and is also a basal type from which still higher branched forms of Valoniaceæ can be derived. The thallus is not encrusted.

Size of thallus.—The specimens collected were small on an average.

	Length.	Width.	Depth.	
Average size,	15 mm.	12 mm.	15 mm.	
Largest size,	35 "	25 "	4 "	(minus rhizoids).
Smallest size,	7 "	5 "	11 "	(with rhizoids).

Color of thallus.—The thalli were of a light transparent green color, sometimes tinged with brown or pink. The rhizoids were vivid green in some cases.

It is possible that the strong green or reddish color is due to the plant being intermixed with such forms as *Halimeda* or some red algæ.

Comparison with other Valoniaceæ.—*Dictyosphæria* might be considered a low type because:

1. Of the primitive, closely appressed branched system.
2. Of the well-developed rhizoids.

Histology.

The five- to six-sided cells on the external surface differ widely in size, some being much enlarged and protruding (*Pl. XV., Fig. 3*). The inner cells and intercellular spaces enlarge toward the center, stretching to abnormal dimensions in older plants.

Cell walls.—The cell walls present a fibrillated appearance, due to a varying number of membrane-like layers (never less

than seven or eight) which compose them. These vary somewhat in number, have an irregular course and protrude to form haptera and needles.

Chemical tests did not show the sphæro-crystals that Murray found in five *Caulerpas*, but not in some Valoniaceæ also tested. The walls are very refractive and present a finely wrinkled appearance on the inner surface, which is not understood.

Inner cell strengthening. — Murray refers to "centripetal membrane point thickenings" in six species of *Caulerpa*. These have been reported only in leaves of *Caulerpa*, rhizoids of *Marchantia* and cells of *Dictyosphæria*. They are merely invaginations of approximately three-fourths of the wall stratifications, into the cavity of the cell at right angles to its depth (*Pl. XV., Fig. 5*).

These needles are formed from the greater portion of the wall and probably softer stratifications. They are refractive, unseptate, colorless, thin-walled and with a waved outline (*Pl. XV., Fig. 7*). The same, of similar structure and development, occur in *Caulerpa*, but differ in being branched many times and interlaced. The present forms are found rarely branched, with either basal (*Pl. XV., Fig. 8*) or apical dichotomy (*Pl. XV., Fig. 9*), yet they can be considered as allied in function, and as a primitive condition of the well-developed cross beams of *Caulerpa*.

Their development occurs as follows: From a minimum (*Pl. XV., Fig. 6*) an increasing number of stratifications invaginate, the inner forming the external wall of the needle. The next stratification passes within this, and this process continues until a varying number have invaginated. Thus the stratifications appear as cross bars, with a lumen between, and a lumen at the base of the needle, the space between the invaginated stratifications and the remaining wall stratifications (*Pl. XV., Figs. 6–9*). The plates explain further details and size. A cross-section proves the theory. The needles occur irregularly over the entire inner surface of the cells of a mature plant, except the upper surface of external cells and the base of rhizoids, where they are absent. The younger plants possess fewer, as there is less strain. From the similarity in structure, origin and branching they can in function be allied to the strengthening structures in *Caulerpa*, which from its large cells needs both the branching interlaced needles and interlaced branches of thallus.

Of Valoniaceæ exposed to like conditions of wind and wave, *Dictyosphæria* needs more firmness. *Valonia* thalli, on account of their form and structure, need no support, and the remaining Valoniaceæ gain sufficient cohesion through interlacing branches.

The presence of the needles may be due to the loose structure of the *Dictyosphæria* thallus, or to the necessity of having an internal balance to the haptera. There is no stimulus to growth from direct contact, as in haptera, and these may arise from strain on older thallus. Whatever the function, it is subsidiary to that of the haptera, as they are less numerous, and chiefly in greater numbers in central cells.

External cell strengthening.—Haptera or intercellular organs of attachment are present in *Udotea*, *Boodlea*, *Microdictyon* and *Spongocladia*, and bind one part of the thallus to another, as in *Struvea*, where they fasten pinna to pinna, or one cell to another as in *Dictyosphæria*. In all cases they bind a thallus of loose structure together.

Origin. — The origin of the haptera is due to the evagination of about one third of the cell wall, similar to the invagination in the case of the needles.

Their primary importance as compared with the needles is perceived, for they are never absent, and no young stages of development are present. They are, however, formed through a similar process, *i. e.*, the evagination of the stratifications. The cross beams, caused by stratifications, are nearer their tips, thus leaving a larger lumen (*Pl. XV.*, *Fig. 10*).

Optical sections near the base appear as dark rings from one to several in number, due to the number of main branches of haptera which are present (*Pl. XV.*, *Fig. 11*).

The haptera are hollow and have no contents.

Development. — The evagination continues until a surface is reached to give the needed stimulus. At this stage the haptere consists of an unbranched tube ending in a closed blunt end *Pl. XV.*, *Fig. 13*). The tube or stalk now begins to lobe dichotomously, and the ends flatten out upon the wall. This continues until a branched circle of lobes is formed, convex and radiating (*Pl. XV.*, *Fig. 10*). The hollow space thus formed between the opposite cell wall and the concave center causes adhesion by sucking (*Pl. XV.*, *Fig. 14*). The base shows from one to three enclosed oval rings, due to the number of main

branches (*Pl. XV., Fig. 11*). The main tubes may develop lobes directly (*Pl. XV., Fig. 11*), or may become branched from one to three times in various directions and levels (*Pl. XV., Figs. 11 and 12*). Each branch then develops (*Pl. XV., Fig. 11*) a separate system of radiating lobes, as seen in cross-section, central view (*Pl. XV., Fig. 12*). As before, the conditions determine size and shape. The haptera are absent from the outer walls of external cells of the thallus, but are abundant elsewhere, and often crowded when developed from the larger cells (*Pl. XV., Fig. 11*). Near the exterior, the closely connected cells cause the haptera to be short-stalked, and after the opposite wall is reached, continued branching occurs over a varying area, limited only by contact with neighboring haptera. In the central cells, longer stalks arise from the separated cells. In the intercellular spaces their length is often much greater, induced by the greater space (*Pl. XV., Fig. 11*). A haptere near the edge of the intercellular space is often two or three times branched, and clasps the surfaces in various directions, to meet the added strain at this position (*Pl. XV., Fig. 11*). The haptera generally extend directly to the opposite cell wall and thus the base from cell 1 alternates with the lobes of cell 2, but they also extend diagonally and at different levels (*Pl. XV., Fig. 11*). The numbers, size of the haptera, length and direction of tubes, number of branches, area of adhesion and position, depend on the distance between the cells.

Rhizoids.—The rhizoids, centrally situated, are elongated, unicellular structures, and are developed from the ventral surface of the thallus. They show little differentiation and correspond to the normal plant cells. They function as primitive holdfasts, attached to the underlying surface of coral, and are thallus cells, enlarged, elongated, irregularly shaped, and, rarely, budded. To strengthen attachment to substratum, haptera, similar to those above described, are formed from the outer edge of rhizoids. These are few in number (*Pl. XV., Fig. 15*). The relation between the strength of the rhizoids and the position of the plant is intimate, their function being aided by secondary structures, the haptera. The color is generally a strong green, rarely reddish.

The cell wall in form and structure is similar to that of thallus cells. In arrangement the rhizoids are scattered or massed together. In size they vary greatly, the longest five mm. by

one mm., the shortest of barely appreciable length by one half mm. Here as elsewhere the organs are but slightly differentiated and vary in size, structure, and number, according to external conditions (*Pl. XV., Figs. 15 and 16*).

Cell Contents.

Endochrome. — The peripheral layer of cell protoplasm consists of dove-tailed polygonal chromatophores, plate-like and distinctly separated by colorless thread-like lines. This single layer of thin wall plates in outer cells of thallus, is dense, stains deeply, and forms a compact unbroken layer. The attachment of this to the cell wall does not appear a close one as the layer becomes easily detached, and floats separately in water (*Pl. XV., Fig. 17*). The layer (*Pl. XV., Fig. 17*) becomes irregularly perforated, less solid and finally (*Pl. XV., Fig. 18*) in inner cells, consists of widely separated chromatophores, joined by numerous thin granular threads. The endochrome does not project into the cell cavity.

In central cells, few chromatophores are present. One kind of chromatophore only can be distinguished, though the size and shape vary somewhat.

Pyrenoid. — Centrally placed within each chromatophore, is an irregularly spherical body, with thicker walls, and stronger refraction (*Pl. XV., Fig. 18*). *Fig. 18* shows in section the thickened wall and hollow center, but does not show the central grain or clefts which are present.

The development of the pyrenoid can be clearly traced. In early stages (*Pl. XV., Fig. 19*) it is more spherical and solid, except for the beginning of a cleft from the outer edge, which cuts to the central grain. This latter enlarges and becomes more irregular in outline, later. More divisions occur, in one plane only., and four to six lobes are formed, all converging to the inner grain, beyond whose outer edge the cleft does not continue. This latter is spherical, thick-walled, refractive, and contains a minute central grain (*Pl. XV., Fig. 20*). Acid fuchsin differentiates the pyrenoid and accompanying starch grains clearly.

Starch grains. — A weakened iodine solution give this characteristic starch reaction. The starch grains show concentric layering and vary in shape from oval and spherical to irregular shapes. They are scattered in older stages near the pyrenoids or throughout the chromatophore (*Pl. XV., Fig. 20*). In

younger plants they are formed against and within the pyrenoid (*Pl. XV., Fig. 19*), from which they seem to have origin, and from which they gradually move, until eventually the majority lie beyond or against the pyrenoid. A small chromatophore generally has from one to three starch grains a larger one five to eight, or even more.

Oil drops.—The large oil drops are scattered irregularly throughout the endochrome, abundant in number. They are differentiated from other protoplasmic structures by large size, lighter color, regular outline, and stronger refraction.

Cell sap.—The cell is entirely filled with a large amount of watery colorless fluid, whose composition was not investigated.

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Explanation to Plate XV.

Figure 1. Form of typical thallus, two fifths natural size.

2. Irregular form of older thallus caused by rupturing of membrane, two fifths natural size.

3. Thallus showing irregularity of upper surface cells, two fifths natural size.

4. Cross section of thallus showing closely appressed outer cells and increasing separation of inner cells, × 168.

5. Cross section showing interior needles of cell, × 45.

6. Cross section showing early development of needle, × 488.

7. Origin of needles, × 488.

8. Basal dichotomous branching of needle, × 488.

9. Apical dichotomous branching of needle, × 488.

10. Origin of haptera; development of two main branches; surface extension of lobes and cross beams, × 212.

11. Diagram of intercellular space showing oval rings representing main branches; wide and narrow expansion of lobes; branching in various directions and at different levels: stalks or main branches of various lengths.

12. Cross section of three main branches, ventral and hollow stalks, × 464.

13. Youngest development of stalk of haptere, × 424.

14. Concave center of haptere from ventral view, × 360.

15. Rhizoid on ventral surface with haptere, × 45.

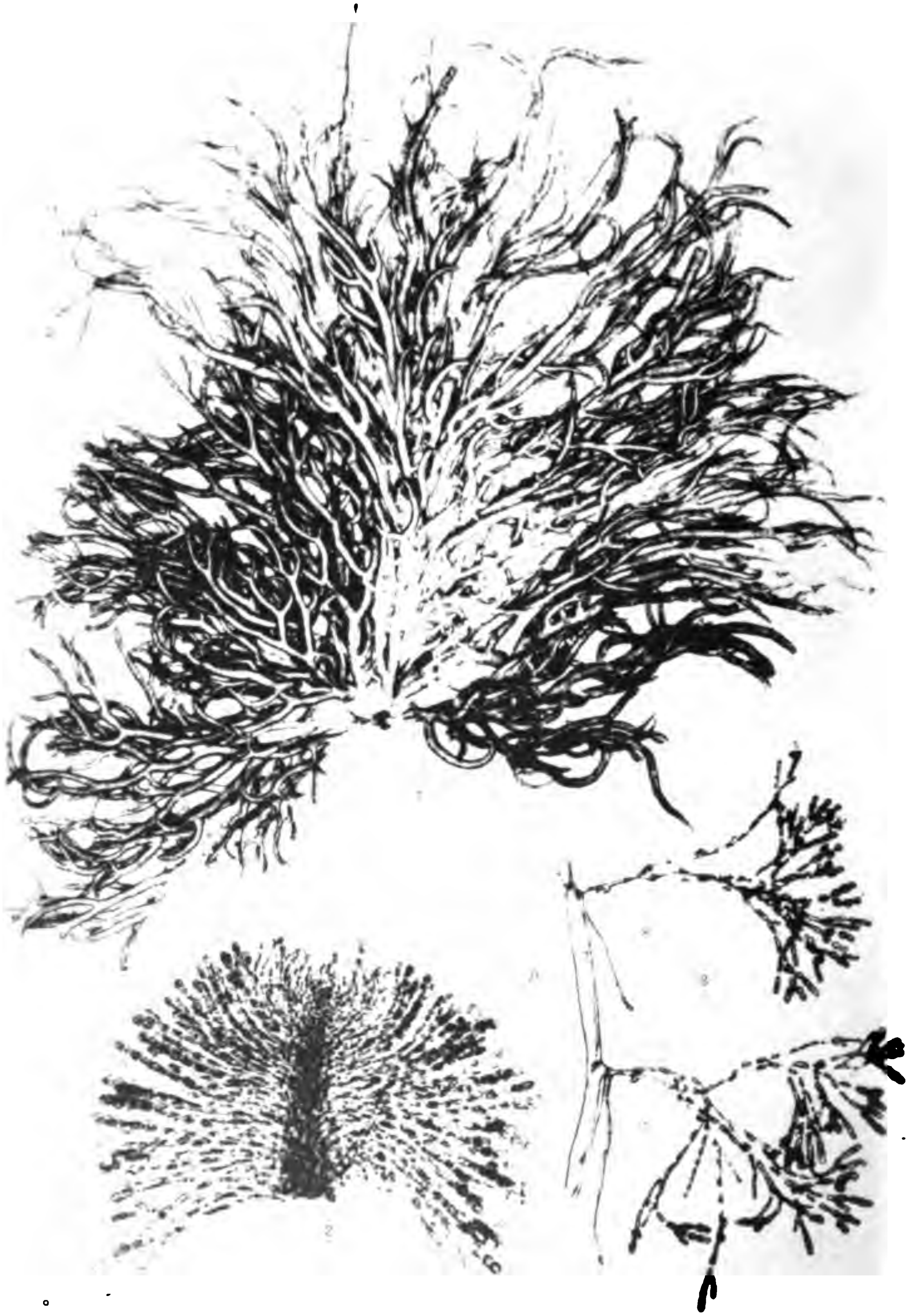
16. Youngest development of foot on ventral surface, × 45.

17. Peripheral protoplasmic layer of chromatophores, × 35.

18. Widely separated chromatophores of inner cell, × 318.

19. Early development of pyrenoid with central grain and formation of first starch grains, × 760.

20. Older stage of pyrenoid; scattered starch grains and central grain, × 760.



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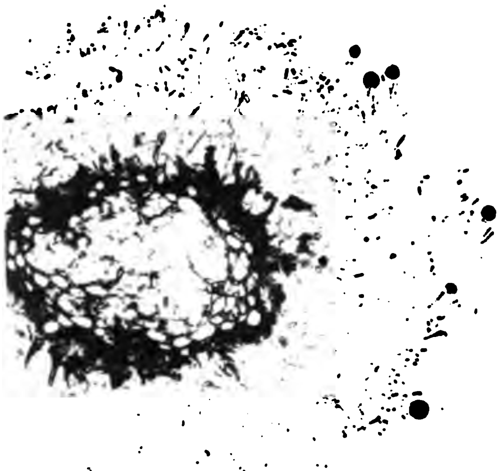

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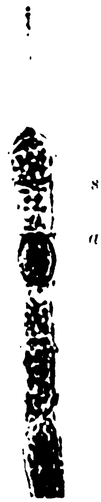

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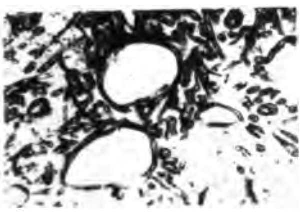

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VIII. STAPFIA CYLINDRICA IN MINNESOTA.

Charles J. Brand.

The material on which these observations are based was collected by the writer during August, 1901, in the harbor of Grand Marais on the north shore of Lake Superior. It has also been observed at Tobin and Washington harbors on Isle Royale, Michigan.

At Grand Marais the plant was found growing in the water, attached to the smooth diabasic rock, at a depth varying from six inches to eight feet. It was most abundant in a small arm of the harbor which is enclosed on two sides by a reef and on a third by a dock crib. The situation is one that does not ordinarily require any particular ability or adaptation for resisting very violent wave action. However, there are times when the plant is compelled to undergo considerable strain. In the event of a strong wind shoreward the seas break over the outer protecting barrier reef and cause a very strong current from the small arm into the harbor proper and also a fairly violent wave action.

The water in which the collection was made is very fresh and cold, in fact it is the drinking water of the villagers residing about the harbor.

It seemed at first that the plant was simply a species of *Tetraspora*, but a careful examination leaves no doubt but that it belongs to the genus *Stapfia*, established by Chodat in 1897.

In the present form the position of the thallus in its usual condition of growth is always upright. The mode of attachment is by means of a distinct holdfast. Just above the holdfast there is a short attenuated area, beyond which the thallus assumes its ordinary diameter. This feature can readily be observed by reference to the figure of the entire plant (*Pl. XVI., Figs. 1, 2, 3*).

An examination of the thallus with the dissecting microscope or even without a lens, reveals a much wrinkled and folded sur-

face. The color is uniformly a very dilute green. The gelatinous thallus is firm and slippery.

A species of *Bulbochæte* was found very commonly growing as an epiphyte on the plant, being attached by a sort of subspherical cell imbedded in the gelatinous mass of the *Stapfia* thallus. Diatoms and desmids were also found in great numbers in the interior of the thallus.

The material used for this study was preserved in 2 per cent. formaline and as a consequence was rather unfavorable for cytological investigation.

After washing the material for about thirty-six hours in water, it was passed through the usual series of alcohols and xylols into paraffine. The plants were permitted to remain in each for a short time only, as they were very prone to grow hard and brittle, especially if left too long in the higher per cents. of alcohol or in xylol. The material was suitably imbedded for securing both longitudinal and transverse sections. The sections were mounted in series and cleared in the usual manner.

After trying numerous stains, it was found that gentian violet and Bismarck brown were the most useful. A concentrated aqueous solution of the Bismarck brown was used and the mounted sections were allowed to remain in this for about two hours. Only a 2 per cent. aqueous solution of the gentian violet was used and the slides were left in the stain for about three minutes. Canada balsam was used as the mounting medium.

The cross-sections disclosed some very interesting foldings of the gelatinous membrane, which cause the perforate appearance seen in the diagrammatic sketch of the transverse section (*Pl. XVI., Fig. 4*) and also in the longitudinal section (*Pl. XVI., Fig. 6*). The cross-section reveals no particular method in the grouping of the cells in the gelatinous structure. The cells are distributed in a single peripheral layer. They appear to be in groups of two and four for the most part, but also in threes and singly in the older thalli.

The longitudinal section (*Pl. XVI., Fig. 7*) does not differ in essential features from the transverse, although the folds are much more clearly distinguishable. This cut also shows clearly the sort of alveolar structure of the interior of the thallus, of which I have been unable to find any mention in the descriptions of either *Stapfia* or *Tetraspora*. This may be the adapta-

tion by which buoyancy is secured and the ordinary upright position of the thallus is made possible. The structure may be produced by the degeneration of the gelatin of the interior.

The plant very strongly resembles *Enteromorpha intestinalis* of marine waters in its pale green color, subtubular thallus, variability in size and attenuate base.

The plants of Nordstedt, Wittrock and Lagerheim, no. 1362, distributed as *Tetraspora cylindrica* (Wahlenb.) Ag. f. *enteromorphoides* Lagerh. nov. form, which, according to Chodat, no doubt belongs to the genus *Stapfia*, resembles the Lake Superior form considerably, though there are some dissimilarities as may be seen by a comparison of the two. The thallus of the former is fistulose, while that of the Lake Superior plant is subfistulose or alveolar. They agree in that both are verrucose, but disagree in that the former may sometimes be ramose, the latter never. The former is described by Lagerheim as "fragili," while the latter is firm and quite tough. They differ also in color, the former being of a much darker green. The Lake Superior form, however, is darker in color in quiet, less fresh, water. The former has rather short thalli in comparison to the diameter, while the Lake Superior plant has a thallus long and of relatively small diameter. The former is much like the larger of the type specimens distributed by Stapf as *Stapfia cylindrica*, while the latter resemble very much the slender and relatively much longer specimens of the same distribution. There is also the great difference in habitat, the one being found in the largest of the fresh-water lakes and the other in a swift-flowing alpine stream of northern Norway.

Exteriorly the plant resembles most strongly the specimens distributed by Rabenhorst as no. 2244, *Tetraspora cylindrica*. There is, however, a greater variance in length. The shortest of my specimens are about as long as the longest of Rabenhorst, while the longest are nearly as long as Wittrock and Nordstedt's *Tetraspora cylindrica* forma *rivularis*. The former were collected on rocks in Lake Wettern, near Jonköping, Sweden, by Nordstedt, and the latter were also collected by him near Kongsvold, Norway, in the river Driva.

The Lake Superior form may be described as follows:

Thallus 2–5 mm. in diameter, 6 cm. to 3 dec. in length, dilute green in color, erect, gelatinous, cylindrical, subfistulose, sometimes rugose-verrucose, unbranched, firm, rather tough,

clavate at distal end, suddenly attenuate at the base into a brief stipe; holdfast disc-shaped; cells spherical, solitary or in groups of two, four or rarely three, 4–16 mic. in diameter. Attached to rocks at lake bottom.

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Chodat, R. Algues vertes de la Suisse, 112. *pl. 49, 52.* 1902.

EXPLANATION OF PLATE XVI. (IN PART).

Figures 1, 2, 3. Plants one half natural size.
4. Diagram of transverse section.
5. Cross-section of thallus, × 235.
6. Longitudinal section of thallus showing fold, × 120.
7. Longitudinal section of thallus, × 235.

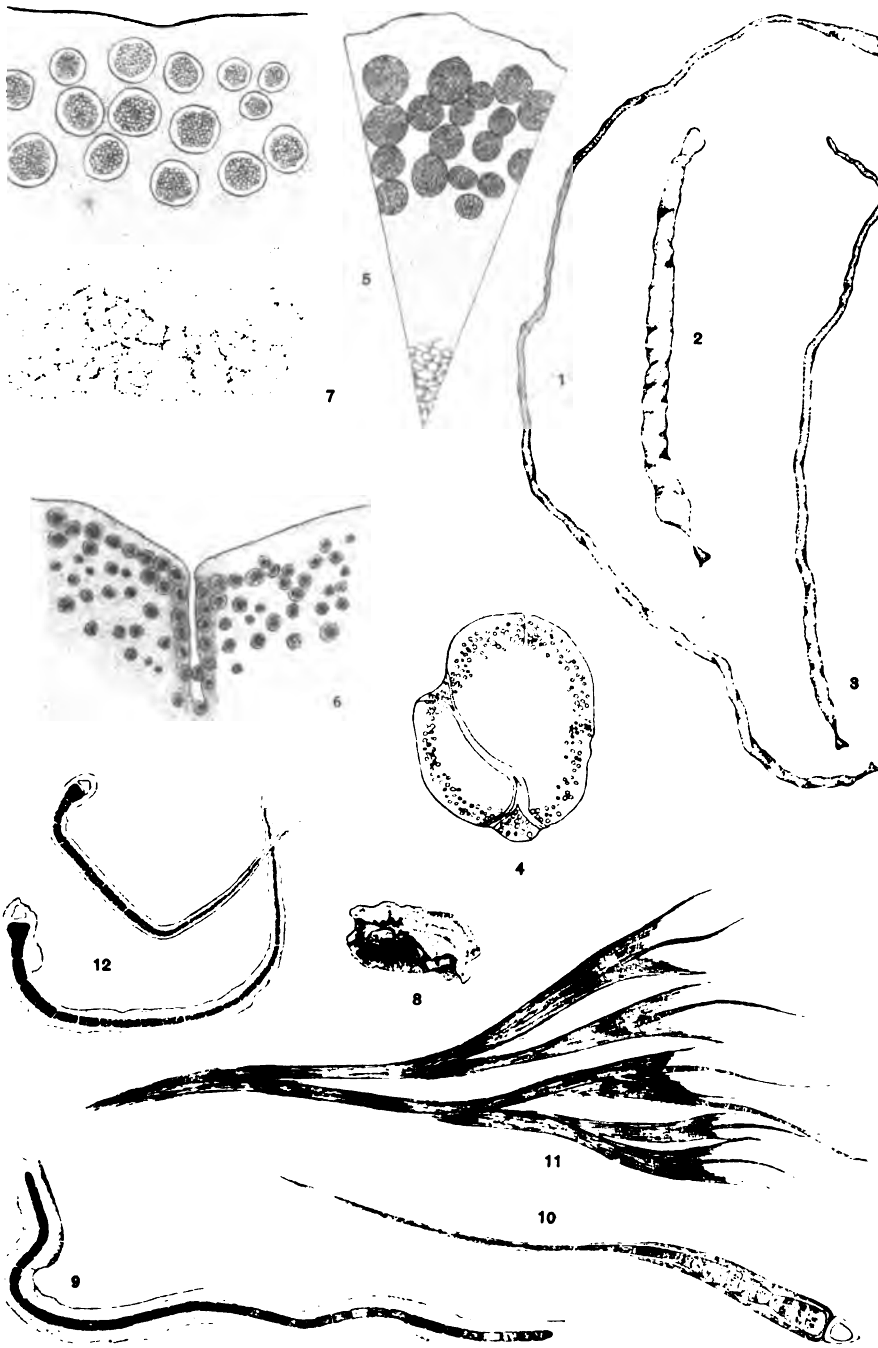

PLATE XVI.

HELIOTYPE CO., BOSTON.

IX. OBSERVATIONS ON SOME CALCAREOUS PEBBLES.

CHALMER POWELL.

The first account of pebbles formed by algæ in the United States is given by Dr. George Murray (1). The pebbles examined by him were found in eight feet of water on the sandy bottom of a Michigan pond separated from Lake Michigan by a sand-bar. The specimens varied in size from one to three and a half inches in diameter, were hollow and showed a stratified or concentrically zoned structure. Upon decalcification they were found to be composed of a densely interwoven mass of filaments. The predominating kind was a species of *Schizothrix*, *S. fasciculata* Gomont. There were also filaments of *Stigonema* and *Dichothrix* and a large number and variety of diatoms.

Mr. Thiselton-Dyer (2) refers to the occurrence of pebbles on the bottom of Lough Belvedere, near Mullingar, which were "of all sizes up to that of a filbert." The bulk of the algal mass consisted of a *Rivularia*.

The first mention of calcareous pebbles in American literature was made by Professor Conway MacMillan (3), who states that although he had "not yet found any of these algal pebbles in lakes of Minnesota, it is probable that they occur." This prediction was realized in June, 1901.

In describing pebbles found along the shore of Littlefield lake, Michigan, Mr. Charles A. Davis (4) states that they are "the result of the development and growth of an alga, *Zonotrichia*, or a nearly related species. The vegetable origin of these pebbles would not be suspected until one recently taken from the water is broken open, when it is found to show a radial structure of bluish-green lines." In a preceding article the same author (5) describes a blue-green alga concerned in the formation of marl, which had been determined to be a species of *Zonotrichia* or some closely related genus. "The plant grows in relatively long filaments formed by cells grow-

ing end to end, and as they grow the filaments become encased in calcareous sheaths. The feature of the plant which makes it important in this discussion, however, is its habit of growing in masses or colonies. The colony seems to start at some point of attachment or on some object like a shell and to grow outward radially in all directions, each filament independent of all others and all precipitating calcium carbonate tubules. The tubules are strong enough to serve as points of attachment for other plants, and these add themselves to the little spheroid and entangle particles of solid matter, which in turn are held by new growths of the lime-precipitating *Zonotrichia* and thus a pebble of greater or less size is formed, which, to the casual observer, is in no wise different from an ordinary water-rounded pebble. These algal calcareous pebbles show both radial and concentric structure and might well be taken for concretions formed by rolling some sticky substance over and over in the wet marl on which they occur, but for the fact that a considerable number of them show eccentric radial arrangement and that the shells of accretion are likewise much thicker on one side than on the other, and finally, because the side which rests on the bottom is usually imperfect and much less compact than the others. The pebbles are characteristically ellipsoidal in shape. The radial lines, noticeable in cross-sections of the pebbles, are considered by the writer to be formed by the growth of the filaments, while the concentric lines probably represent periods of growth of the plants, either seasonal or annual." Other forms than the *Zonotrichia* were found in the pebbles.

In June, 1901, Messrs. Freeman and Lyon, of the Botanical Department of the University of Minnesota, found some calcareous pebbles in Clearwater lake, Wright county, Minnesota. This lake covers an area of about four square miles and is really two lakes connected by a narrow strait. The pebbles were collected from the southern arm. They were found lying in from four to ten feet of clear water on sand-bars, which rose abruptly towards the surface and at their edges sloped almost perpendicularly into deep water.

These pebbles range in size from that of a small hickory nut to two inches in diameter. Most of them are flattened, and, though comparatively smooth in some cases, are often rough, coagulated and wave-worn. All are more or less hollow. In section they have a distinctly stratified appearance. The theory

of Mr. Davis given above is the most probable one for their formation.

A study was made of the pebbles which had been preserved in 5 per cent. formalin. Sections cut with a sharp scalpel were placed in a weak solution of hydrochloric acid until decalcified, after which they were immediately mounted in glycerine jelly. The pebbles were found to be composed of a densely interwoven mass of filaments of which the most common type was those of *Schizothrix fasciculata* Gomont. The trichomes were 1.4 to 3 mic. broad. The pseudocysts were equal in length to diameter of trichome or twice as long, 1.2 to 3.5 mic. long. A species of *Calothrix*, two species of *Cosmarium*, a *Nostoc* and numerous diatoms were also present in the pebbles.

In June, 1901, Miss Daisy Hone collected some small pebbles at Point Douglas, Minn., on a steep bluff side overlooking the Mississippi river. Being high above the water they were not supplied with moisture and seemed perfectly dry at the time of collection. These pebbles had an outside layer of calcareous material, which, when decalcified, showed the presence of an alga, a species of *Scytonema*.

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1. **Murray, G.** Phyc. Mem. 74–77. 1895.
2. **Thiselton-Dyer, W. T.** Ann. Bot. **5**: 225. 1890–91.
3. **MacMillan, C.** Minn. Plant Life, 41. 1899.
4. **Davis, C. A.** Journ. Geol. **8**: 502. 1900.
5. **Davis, C. A.** Journ. Geol. **8**: 495. 1900.

Explanation of Plates.

Plate XVI. (in Part).

Figure 8. A section of a pebble showing stratified layers, nat. size.

9. A filament of *Schizothrix*, × 600.

10. *Calothrix* sp. Detail of an older filament, × 335.

11. Same. Portion of thallus showing method of branching, × 64.

12. Same. Young free filaments, × 200.

Plate XVII.

Figures 1–5. Calcareous pebbles, one half natural size.

1. Pebble showing smooth surface.

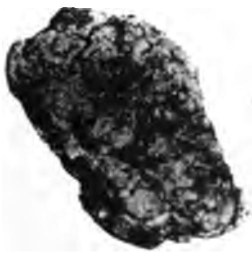
2. One showing a rougher surface.

3. One showing a still rougher and more porous surface, probably wave-worn.

4 and 5. Hollow interiors of two pebbles are shown.

1

2



3

4

5

6

PLATE XVII.

HELIOTYPE CO., BOSTON.

X. NITELLA BATRACHOSPERMA IN MINNESOTA.

Gene Lilley.

The first record of *Nitella batrachosperma* was made in 1833 by Reichenbach who called it *Chara batrachosperma*. In 1847 A. Braun (1) placed it with the Nitellæ.

The plant is quite widely distributed in Europe. Migula states that it has been reported from Germany, Switzerland, Sweden, Finland, France, Austria, Italy, Spain and that also it has been reported from Australia and North America. During the summer of 1898 A. J. Pieters, Assistant Botanist of the Department of Agriculture, collected *Nitella batrachosperma* at East Harbor, Ohio. He describes the habitat as follows: "At East Harbor there is a wide stretch of swamp intersected by channels which open into the lake by one deep and narrow channel protected from severe wave action by a sand-bar. . . A short distance from the entrance, the channel divides, one branch going east, the other west. . . . Just where the channel turns toward the east is a sandy beach covered with two feet or less of water, and here grow several species of Characeæ, which are more abundant here than elsewhere in the swamp. *Nitella tenuissima* and *N. batrachosperma* grow in about one foot of water with their branches spread out flat on the sand."

Nitella batrachosperma was collected in Minnesota by the writer in August, 1901, at Pike lake, a small shallow lake twelve miles west of Duluth. The plants grew on a sandy beach where the water was from three to six inches deep. The east end of the lake is the only part where the beach is sandy, and although the shore around the lake was examined carefully it was only at this one place that the plants were seen. *Chara coronata* Ziz. was found with *N. batrachosperma*. *N. tenuissima* Desv., which is usually reported with *N. batrachosperma*, was not found at this place. The collection was made in the morning when the sun's rays struck the water at such an angle as to light up the sandy bottom, so that the plant could be easily distinguished from *Chara coronata*. The previous afternoon

the plant had been overlooked as its dirty brown or gray color and its low prostrate habit gave it the appearance of débris. Very few plants were found.

Description of plant.—*Nitella batrachosperma* is of a dirty brownish-green color, very small, from 1.8 cm. to 3 cm. high. Most of the plants examined were 2 cm. high. There are from two to four main branches springing from the first node. The branches measure .5 mm. in diameter and from 4–7 mm. to the first whorl of leaves. This whorl of leaves consists of six to eight sterile leaves, having two divisions. The first division or main ray is from 55 to 67.5 mic. wide and 685.5 to 750 mic. long. The leaflets are about the same length and are two-celled, the basal cell being very long, the end cell short and sharp-pointed. The lower sterile leaves are loose and spreading and stand at nearly right angles to the main branch. At the tip of the branch the leaves are thick and compressed, giving a bushy-like appearance to the plant. At the apex both sterile and fertile leaves have from two to three divisions. In a fertile leaf, having three leaflets divided and three undivided, the main ray is 50 mic. broad and 312 mic. long. In a sterile leaf with three leaflets divided and three undivided the diameter of the main ray is 62.5 mic. and the length 312.5 mic. In a sterile leaf having three divisions throughout, the diameter is 80 mic. and the length 250 mic., showing little difference in size of fertile and sterile leaves. The fertile leaves are all borne at the tip of the branch and but lew leaves at the tip are sterile.

Rhizoids. — Rhizoids arise from the first and second nodes of the plant. The rhizoids from the first node are much larger than those from the second, being 125 mic. in diameter, while those from the upper are about 62 mic. wide. The rhizoids have long cells and abut upon one another in the characteristic "stocking-foot" manner of the Characeæ.

Reproduction. — *Nitella batrachosperma* is monœcious. The antheridia and oögonia are usually borne on the same leaf, though not always. Many of the leaves bear only antheridia, few bear only oögonia. The organs can be distinguished only by careful examination as they are minute and the color, a yellowish-brown, differs but little from the color of the plant.

Antheridium. — The antheridia are borne terminally upon the first segment of the leaf. The second and third divisions do not bear antheridia or oögonia. The development of the an-

theridium is very similar to that of *Nitella flexilis*. It can be distinguished very early in the growing point by its position and size. It is at first a large spherical cell having a large nucleus. The first division after the stalk cell is cut off is vertical (*Pl. XVIII., Fig. 10*). The second division is transverse (*Pl. XVIII., Fig. 11*). The unfolding of the walls is seen in the sixteen-celled stage (*Pl. XVIII., Fig. 12*). The shields in the mature state are hyaline and contain few chlorophyll bodies and little coloring matter, so that the contents can be easily made out in optical section. Mature antheridia are 135 by 210 mic. in diameter.

Oögonium. — The oögonium arises at the base of the antheridium and takes the place of a leaflet. But one oögonium is borne on a leaf. All stages of development can be found on the same plant. Two "Wendung-zellen" were observed in *N. batrachosperma* (*Pl. XVIII., Figs. 7 and 8*). The filaments surrounding the egg and crown cells are colorless and hyaline. The oösperm is almost spherical (270 by 300 mic.). It is of a rich, golden brown color.

Bibliography.

Migula, W. Die Characeen, in Rabenhorst, Kryptogamen Flora, 184. 1897.

Pieters, A. J. The Plants of western Lake Erie. U. S. Fish Comm. Bull. 64, 78. 1901.

Description of Plate XVIII.

Figure 1. Photograph of *Nitella batrachosperma*. Twice natural size.

2. Rhizoid showing "stocking-foot" cells with branches, × 300.

3. Outline drawing of fertile leaf showing tip of first division bearing antheridium and oögonium, × 300.

4. Apex of leaf bearing antheridium, oögonium and leaflet, × 150.

5. Apical cell of branch showing three nodal cells, × 300.

6. Apical cell of branch showing nodal cells and last internodal cell, × 300.

7. Young oögonium showing first Wendung-zelle and first division of crown cells, × 300.

8. Young oögonium showing two Wendung-zellen and two cells of the crown, × 300.

9. Membrane of oögonium, much magnified.

10. Young antheridium showing stalk cell cut off and first division of antheridium, × 300.

11. Young antheridium in four-celled stage, × 300.

12. Young antheridium in sixteen-celled stage, with young leaflets, × 300.

13. Young antheridium with shields, × 300.

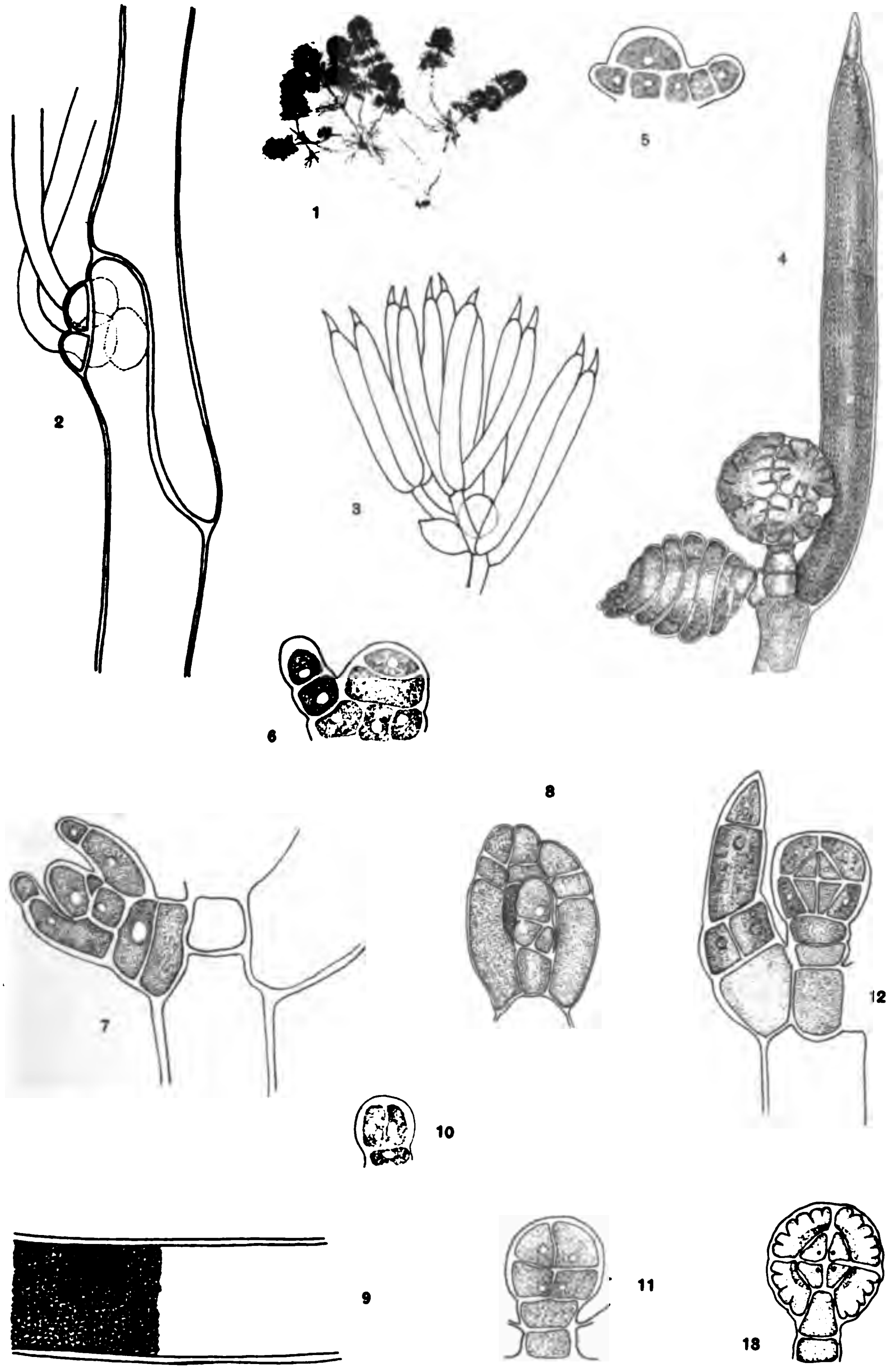


PLATE XVIII.

HELIOTYPE CO., BOSTON.

XI. CATALOG OF MINNESOTA GRASSES.

W. A. Wheeler.

The following catalog of the grasses of Minnesota is a partial report of the work done on the Minnesota Botanical Survey during 1902.

Upham's catalog of the Flora of Minnesota, published in 1884, lists one hundred and thirty-nine species and varieties as occurring within the limits of the state. In the Metaspermæ of the Minnesota Valley, published in 1892, Professor Conway MacMillan lists ninety species and varieties indigenous to the drainage basin of the Minnesota river. Other local reports contain lists of Minnesota grasses. Most of these lists, however, have been incorporated in the two reports just cited.

This catalog of one hundred and seventy-eight species and varieties is based mainly upon a redetermination by the writer of all the specimens of Minnesota grasses in the Herbarium of the University of Minnesota. One hundred and thirty-eight species and varieties have been so determined. The reports of the remaining forty species listed have been taken from previous publications without examination of specimens. Seven of these have been cancelled by corrections in the determination of the specimens cited. Probably others of the forty so listed have also been reported without sufficient evidence or upon incorrect determination, but the specimens are not at hand for comparison. These have, however, all been listed, and are accompanied by notes stating upon what the report is based.

Twenty-four species not previously reported from the state are listed in this catalog. Some of these were determined from lately-published descriptions, without specimens for comparison, and are therefore somewhat doubtful. This refers especially to the species of *Panicum*. Some specimens of *Elymus* remain undetermined because of insufficient material of recently published species for comparison.

Synonyms are given where confusion might arise in a comparison with other Minnesota reports. Herbarium specimens

are cited only when the species is poorly represented by specimens in the Herbarium of the University.

Andropogon scoparius MICHX. Fl. Bor. Am. **1**: 57. 1803. Beard grass.

Common in dry soil throughout.

Herb.: Specimens from all parts of the state.

Andropogon furcatus MUHL. Willd. Sp. Pl. **4**: 919. 1806. Blue stem.

Andropogon provincialis furcatus HACK. in DC. Mon. Phan. **6**: 442. 1889.

Common in dry soil throughout.

Herb.: Specimens from all parts of the state.

Sorghastrum avenaceum (MICHX.) Nash, in Britton, Man. Fl. U. S. and Can. 71. 1901. Indian grass.

Chrysopogon avenaceus BENTH. Journ. Linn. Soc. **19**: 73. 1881.

Common throughout.

Herb.: Numerous specimens.

Syntherisma linearis (KROCK.) NASH, Bull. Torr. Club, **22**: 420. 1895. Small crab-grass.

Panicum glabrum GAND. Agrost. **1**: 22. 1811.

Waste and cultivated ground throughout.

Herb.: Ballard 1168, Goodhue county; Aiton, Hennepin county; Frost 380, Kandiyohi county; Sandberg, Hennepin county; Campbell 179, St. Cloud.

Syntherisma sanguinalis (L.) NASH, Bull. Torr. Club, **22**: 42. 1895. Large crab-grass.

Panicum sanguinale L. Sp. Pl. 57. 1753.

Waste and cultivated ground.

Herb.: Aiton, Minneapolis; Wheeler, Houston county.

Echinochloa crus-galli (L.) BEAUV. l. c. Barnyard grass.

Panicum crus-galli L. Sp. Pl. 56. 1753.

Common as a weed throughout.

Herb.: Numerous specimens.

Echinochloa walteri (PURSH) NASH, in Britton, Man. Fl. U. S. and Can. 78. 1901. Cockspur-grass.

Panicum crus-galli hispidum TORR. Fl. N. Y. **2**: 424. 1843.

Panicum walteri PURSH, Fl. Am. Sept. **1**: 66. 1814

In similar locations to *E. crus-galli* (L.) Beauv., but not so common.

Herb.: A. M. Johnson, Hennepin county; Wheeler, Forest Lake; Aiton, Lake Waseca.

Panicum capillare L. Sp. Pl. 58. 1753. Witch grass.

Common in dry soil throughout.

Herb.: Numerous specimens.

Panicum cognatum SCHULTES, R. & S. Syst. **2**: 235. Diffuse panicum.

Panicum autumnale Bosc. Spreng. Syst. **1**: 320. 1825.

Reported from Minnesota in Upham's catalog, but not represented by specimens in the University herbarium.

Panicum virgatum L. Sp. Pl. 59. 1753. Tall smooth panicum.

Common throughout.

Herb.: Numerous specimens.

Panicum agrostoides SPRENG. Pugill. **2**: 4. Agrostis-like panicum.

Reported from Minnesota in Upham's catalog and in MacMillan's Metaspermæ of the Minnesota Valley, but not represented by specimens in the University herbarium.

Panicum depauperatum MUHL. Gram. 112. 1817. Starved panicum.

Reported from Minnesota by Upham and MacMillan and probably occurs here. Perhaps confused with the two following species.

Panicum linearifolium SCRIBN. in Br. & Br. Illus. Fl. App. **3**: 500. 1898. Narrow-leaved panicum.

Dry soil, south.

The determination of the specimens cited under this and the two following species were made entirely from descriptions without comparison with authentic determinations and are therefore somewhat doubtful.

Herb.: Rosendahl 259, Spring Grove; Holzinger, Winona.

Panicum perlongum NASH, Bull. Torr. Club, **26**: 575. 1899. Elongated panicum.

Dry soil, south.

Herb.: Sheldon, Mille Lacs Indian Reservation, 2686, Brainerd; Ballard 1010, Nicollet county; Sandberg, Hennepin county; Wheeler 1192, Winona.

Panicum werneri Scribn. in Br. & Br. Illus. Fl. App. 3: 501. 1898. Werner's panicum.

Not previously reported from Minnesota.

Herb.: Oestlund, Hennepin county (?).

Panicum angustifolium Ell. Bot. S. C. & Ga. 1: 129. 1817. Taller narrow-leaved panicum.

Panicum consanguineum S. Wats. in A. Gray, Man. Ed. 6, 633, in part. 1890.

Reported from Minnesota in Upham's catalog and MacMillan's Metaspermæ of the Minnesota Valley, but not represented by specimens in the University herbarium.

Panicum dichotomum L. Sp. Pl. 58. 1753. Forked panicum.

The previous reports of this probably refer to some other species, as this species is not known to occur in our range.

Panicum boreale Nash, Bull. Torr. Club, 22: 421. 1895. Northern panicum.

In moist soil. Not previously reported from Minnesota.

Herb.: Sandberg, Hennepin county.

Panicum implicatum Scribn. in Br. & Br. Illus. Fl. App. 3: 498. 1898. Hairy-panicled panicum.

In dry soil throughout (?).

Herb.: Leiberg 2103, Blue Earth county (?); Aiton, Lake Itasca (?).

Panicum unciphyllum Trin. Gram. Panic. 242. Hairy panicum.

Panicum pubescens A. Gray.

Common in dry soil throughout.

Herb.: Numerous specimens.

Panicum leibergii (Vasey) Scribn.; Vasey, U. S. Dept. Agric., Div. Bot. Bull. 8: 32. 1889. Leiberg's panicum.

Common in dry soil south.

Herb.: Numerous specimens.

Panicum scribnerianum Nash, Bull. Torr. Club, 22: 421. 1895. Scribner's panicum.

Panicum pauciflorum A. Gray, Man. 613. 1848.

Common in dry soil south.

Herb.: Specimens collected throughout southern Minnesota.

Panicum xanthophysum A. GRAY, Ann. Lyc. N. Y. 3: 233. 1835. Slender panicum.

Dry soil throughout.

Herb.: Aiton, Lake Itasca; Sheldon, Mille Lacs Indian Reservation, 2831 Kanabec county; Schuette, St. Anthony Park; Ballard 1419, Cass county.

Panicum porterianum NASH, Bull. Torr. Club, 22: 420. 1895. Broad-leaved panicum.

Panicum latifolium WALT. Fl. Car. 73. 1788.

Common in woods south.

Herb.: Rosendahl 210 and 487, Wheeler 388, Houston county; Oestlund, Sandberg, Aiton, Hennepin county; Ballard 487, Scott county; Taylor 1599, Lindstrom; Hvoslef, Lanesboro.

Chætochloa verticillata (L.) SCRIBN. U. S. Dept. Agric., Div. Agrost. Bull. 4: 39. 1897. Fox-tail grass.

Setaria verticillata BEAUV. Agrost. 51. 1812.

Reported in Upham's catalog but not represented by specimens.

Chætochloa glauca (L.) SCRIBN. U. S. Dept. Agric., Div. Agrost. Bull. 4: 39. 1897. Yellow pigeon-grass.

Setaria glauca BEAUV. Agrost. 51. 1812.

Abundant as a weed throughout.

Herb.: Numerous specimens.

Chætochloa viridis (L.) SCRIBN. U. S. Dept. Agric., Div. Agrost. Bull. 4: 39. 1897. Green pigeon-grass.

Setaria viridis BEAUV. Agrost. 51. 1812.

Abundant as a weed throughout.

Herb.: Numerous specimens.

Chætochloa italica (L.) SCRIBN. U. S. Dept. Agric., Div. Agrost. Bull. 4: 39. 1897. Hungarian millet.

Setaria italica R. & S. Syst. 2: 493. 1817.

Locally escaped from cultivation.

Herb.: Foote, Worthington; Sandberg, Hennepin county.

Cenchrus tribuloides L. Sp. Pl. 1050. 1753. Sand-bur, Bur-grass.

Common in sandy soil throughout.

Herb.: Many specimens.

Zizania aquatica L. Sp. Pl. 991. 1753. Wild rice, Indian rice.

Common in shallow water and swamps throughout.
Herb.: Numerous specimens.

Homalocenchrus virginicus (WILLD.) BRITTON, Trans. N. Y. Acad. Sci. **9**: 14. 1889. White grass.
Leersia virginica WILLD. Sp. Pl. **1**: 325. 1797.
Infrequent south.
Herb.: Sandberg, Oestlund, Aiton, Hennepin county; Ballard 1172, Zumbrota; Sandberg, Goodhue county; Wheeler 564, Houston county.

Homalocenchrus oryzoides (L.) POLL. Hist. Pl. Palat. **1**: 52. 1776. Rice cut-grass.
Leersia oryzoides Sw. Fl. Ind. Occ. **1**: 132. 1797.
Common throughout in moist places.
Herb.: Numerous specimens.

Homalocenchrus lenticularis (MICHX.) SCRIBN. Mem. Torr. Club, **5**: 33. 1894. Catch-fly grass.
Leersia lenticularis MICHX. Fl. Bor. Am. **1**: 39. 1803.
Rare southeast.
Herb.: Lyon 713, Houston county.

Phalaris arundinacea L. Sp. Pl. 55. 1753. Reed canary grass.
Common in moist soil throughout.
Herb.: Numerous specimens.

Phalaris canariensis L. Sp. Pl. 54. 1753. Canary grass.
Adventive throughout.
Herb.: Well represented by specimens.

Anthoxanthum odoratum L. Sp. Pl. 28. 1753. Sweet vernal grass.
Adventive southeast.
Herb.: Holzinger 3556, Winona.

Savastana odorata (L.) SCRIBN. Mem. Torr. Club, **5**: 34. 1894. Holy grass, Vanilla grass.
Hierochloa borealis R. & S. Syst. **2**: 513. 1817.
Hierochloa odorata fragrans (WILLD.) RICHT. Pl. Eur. **1**: 31. 1890.
Common throughout the state especially in the northern part. One of our very earliest grasses.
Herb.: Sheldon 175, Blue Earth county, 2062, 2367, Aitkin county; Sandberg, Goodhue and Hennepin counties; Aiton,

Hubbard county; Frost, Minneapolis; Bailey, Vermilion Lake; Sedge, Detroit.

Aristida curtissii (A. GRAY) NASH in Britton, Man. 94. 1901. Curtiss's three-awned grass.

In dry soil. Not previously reported from Minnesota.

Herb.: Upham, Minneapolis, 1884.

Aristida basiramea ENGELM. Vasey, Coult. Bot. Gaz. 9: 76. 1884. Poverty grass. Three-awned grass.

Frequent in dry soil south.

Herb.: Sandberg, Wollan, Aiton, Hennepin county; Holzinger, Winona county; Sandberg, Crow Wing county; Sheldon 6169, Taylors Falls.

Aristida longiseta robusta MERRILL, U. S. Dept. Agric., Div. Agrost. Cir. 34: 5. 1901. Long-awned aristida.

Aristida purpurea of authors, not NUTT.

Infrequent in dry soil southwest.

Herb.: Leiberg, Rock and Blue Earth counties; Skinner, Heron lake; Sheldon, Lake Benton.

Aristida purpurea NUTT. Trans. Am. Phil. Soc. 5: 145. 1837.

All reports of this species from Minnesota should be referred to *Aristida longiseta robusta* Merrill.

Aristida purpurascens POIR. in Lam. Encycl. Suppl. 1: 452. 1810. Purplish aristida.

Reported from Minnesota by Lapham but probably of doubtful occurrence.

Aristida tuberculosa NUTT. Gen. 1: 57. 1818. Sea-beach aristida.

Reported from Minnesota by Lapham but is not represented by specimen in the University herbarium.

Stipa macouni SCRIBN.; Macoun, Cat. Can. Pl. 5: 390. 1890. Macoun's stipa.

Reported from north shore of Lake Superior by Macoun. No Minnesota specimens known to have been collected.

Stipa viridula TRIN. Mem. Acad. St. Petersb. (VI.) 2: 39. 1836. Green stipa.

Rare, west.

Herb.: Skinner 41, Heron lake.

Stipa avenacea L. Sp. Pl. 78. 1753. Black oat-grass.

Reported by E. P. Sheldon in the Minnesota Botanical Studies from Poplar Island lake, Ramsey county. The speci-

men so labelled in the University herbarium is *Stipa comata* Trin. & Rupr. There are no Minnesota specimens of *Stipa avenacea* in the University herbarium.

Stipa comata TRIN. & RUPR. Agrost. 3: 75. 1842. Western stipa.

Not previously reported from Minnesota.

Herb.: Sheldon, Poplar Island lake, St. Anthony Park.

Stipa spartea TRIN. Mem. Acad. St. Petersb. (VI.) 1: 82. 1831. Porcupine grass, Devil's darning-needle.

Common on dry soil throughout.

Herb.: Numerous specimens.

Oryzopsis canadensis (POIR.) TORR. Fl. N. Y. 2: 433. 1843. Slender mountain rice.

Oryzopsis juncea (MICHX.) B.S.P. Prel. Cat. N. Y. 67. 1888.

Common in the vicinity of the headwaters of the Mississippi river and probably extending throughout northern Minnesota.

Herb.: Lyon, Rosendahl, Butters and Wheeler, and Aiton, Lake Itasca; Sheldon 2071 and 2347, Aitkin county, 2012, Brainerd; Anderson 407, Cass county.

Oryzopsis asperifolia MICHX. Fl. Bor. Am. 1: 51. 1803. White mountain rice.

Common north of the twin cities, rare south.

Herb.: Sheldon, 4561, Lake county, 2097, Aitkin county, 1926 Hennepin county, 4613 Tower, 6192 Taylors Falls; Ballard, Cass county; Lyon, Rosendahl, Butters and Wheeler, 38, Lake Itasca.

Oryzopsis melanocarpa MUHL. Gram. 79. 1817. Black mountain rice.

In woods throughout?

Herb.: Sandberg, Herrick, Aiton, MacMillan, Hennepin county; Ballard 1794, Cass county; Campbell, St. Cloud; Taylor 949, Glenwood; Sandberg, Isanti county.

Milium effusum L. Sp. Pl. 61. 1753. Tall millet-grass.

Rare in moist woods. Not previously reported from Minnesota.

Herb.: Sheldon 164, Waseca county, 2996, Milaca; Wheeler, Ramsey county.

Muhlenbergia sobolifera (MUHL.) TRIN. Unifl. 189. 1824. Rock muhlenbergia.

Reported from Minnesota but not represented by specimens. Probably does not occur here.

Muhlenbergia mexicana (L.) TRIN. Unifl. 189. 1824. Meadow muhlenbergia.

Common throughout.

Herb.: Numerous specimens.

Muhlenbergia racemosa (MICHX.) B.S.P. Prel. Cat. N. Y. 67. 1888. Wild timothy.

Muhlenbergia glomerata TRIN. Unifl. 191. 1824.

Common throughout.

Herb.: Numerous specimens.

Muhlenbergia sylvatica TORR. Fl. U. S. 1: 87. 1824. Wood muhlenbergia.

Rare along eastern border.

Herb.: Sandberg, Hennepin county.

Muhlenbergia ambigua TORR. Nicollet's Rep. 164. 1843. Minnesota muhlenbergia.

Herb.: Type from Lake Okaman in Columbia University. Not examined for this report.

Muhlenbergia tenuiflora (WILLD.) B.S.P. Prel. Cat. N. Y. 67. 1888. Slender muhlenbergia.

Muhlenbergia willdenovii TRIN. Unifl. 188. 1824.

Reported from southern Minnesota in Upham's catalog. No Minnesota specimens in the University herbarium.

Muhlenbergia diffusa SCHREB. Beschr. Gras. 2: 143. *pl. 51.* 1772–1779.

A collection of John Leiberg from Blue Earth county and one by E. P. Sheldon from Otter Tail county, reported in the Metaspermæ of the Minnesota Valley and Minnesota Botanical Studies as *Muhlenbergia diffusa* Shreb., are not this species, but are very slender forms of *Muhlenbergia mexicana* (L.) Trin. There are no authentic collections known from Minnesota.

Brachyelytrum erectum (SCHREB.) BEAUV. Agrost. 39. 1812. Bearded short-husk.

Brachyelytrum aristatum R. & S. Syst. 2: 413. 1817.

Infrequent in moist places.

Herb.: Sandberg, Aiton, Hennepin county; Ballard 397, Scott county; Bailey 397, Mud Lake; Sandberg, Aitkin county.

Phleum pratense L. Sp. Pl. 59. 1753. Timothy.

Escaped from cultivation throughout.

Herb.: Numerous collections.

Alopecurus geniculatus L. Sp. Pl. 60. 1753. Marsh foxtail.

The flowering glume of this species, with its geniculate awn about twice the length of the glume, clearly distinguishes this from the next, with its straight awn barely equalling the glume in length.

Rare in moist places southwest. All previous reports refer to the following species.

Herb.: Moyer, Montevideo; Lugger, Pipestone.

Alopecurus fulvus SMITH, Engl. Bot. *pl. 1467.* 1793. Marsh foxtail.

Alopecurus geniculatus fulvus SCRIBN. Mem. Torr. Club, **5**: 38. 1894.

Alopecurus geniculatus aristulatus TORR. Fl. U. S. **1**: 97. 1824.

Common in wet soil throughout.

Herb.: Well represented by collections from all parts of the state.

Alopecurus pratensis L. Sp. Pl. 60. 1753. Meadow foxtail.

Locally escaped from cultivation.

Herb.: Chapman, Hennepin county.

Sporobolus asper (MICHX.) KUNTH. Enum. **1**: 210. 1833.

Reported from Minnesota in Upham's catalog. Probably does not occur in this state.

Sporobolus vaginæflorus (TORR.) WOOD, Classbook, 775. 1861.

Reported from Minnesota but probably does not occur here. Illinois is given as the northwestern limit in Britton's Manual.

Sporobolus neglectus NASH, Bull. Torr. Club, **22**: 464. 1895. Small rush-grass.

Dry places, rare. Not previously reported from Minnesota.

Herb.: Sheldon 3820, Otter Tail county (?).

Sporobolus brevifolius (NUTT.) SCRIBN. Mem. Torr. Club, **5**: 39. 1895. Short leaved rush-grass.

Sporobolus depauperatus SCRIBN. Bull. Torr. Club, **9**: 103. In part. 1882.

Prairie region, southwest.

Herb.: Sheldon, Brown's Valley, Lake Benton; Menzel, Pipestone.

Sporobolus cuspidatus (TORR.) WOOD, Bot. and Fl. 385. 1870. Prairie rush-grass.

Sporobolus brevifolius SCRIBN. Mem. Torr. Club, **5**: 39. In part. 1895.

Dry soil throughout except northeast.
Herb.: Well represented by collections.

Sporobolus ejuncidus NASH in Britton, Man. 106. 1901. Purple dropseed-grass.
Sporobolus junceus (MICHX.) KUNTH. Rev. Gram. **1**: 68. 1835.
Reported from Wisconsin and Minnesota by Lapham. This report is probably incorrect, as neither of these comes within the known range of the species.

Sporobolus cryptandrus (TORR.) A. GRAY, Man. 576. 1848. Sand dropseed-grass.
In sandy soil throughout.
Herb.: Sheldon, Oestlund, Aiton, Hennepin county; Sheldon 3435 and 3362, Otter Tail county; Campbell, Stearns county.

Sporobolus heterolepis A. GRAY, Man. 576. 1848. Strong-scented dropseed.
In dry soil throughout.
Herb.: Collections from Hennepin, Otter Tail, Lincoln, Goodhue, Traverse, Winona and Blue Earth counties.

Cinna arundinacea L. Sp. Pl. 5. 1753. Indian reed.
Swamps, infrequent.
Herb.: Sandberg, Isanti county; Ballard 1173, Zumbrota.

Cinna latifolia (TREV.) GRISEB. in Ledeb. Fl. Ross. **4**: 435. 1853. Slender Indian reed.
Cinna pendula TRIN. Mem. Acad. St. Petersb. (VI.) **6**: 280. 1841.
In moist soil north.
Herb.: Bailey 323, St. Louis river; MacMillan & Sheldon 85, Brainerd; Sandberg, Hennepin county.

Agrostis alba L. Sp. Pl. 63. 1753. Red-top.
Agrostis vulgaris WITH. Bot. Arr. Brit. Pl. Ed. 3, 132. 1796.
Agrostis alba vulgaris THURBER in A. Gray, Man. Ed. 6, 647. 1890.
Escaped from cultivation throughout Minnesota.
Herb.: Numerous specimens.

Agrostis canina L. Sp. Pl. 62. 1753.
Reported from Pipestone county in Upham's catalog. Of doubtful occurrence in the state.

Agrostis perennans (WALT.) TUCKERM. Am. Journ. Sci. **45**: 44. 1843. Thin grass.

Rare in moist places.

Herb.: Sandberg, Isanti and Hennepin counties.

Agrostis hyemalis (WALT.) B.S.P. Prel. Cat. N. Y. 68. 1888. Tickle-grass, Rough hair-grass.

Agrostis scabra WILLD. Sp. Pl. **1**: 370. 1798.

Common throughout.

Herb.: Very numerous collections.

Calamagrostis breviseta lacustris KEARNEY, U. S. Dept. Agric., Div. Agrost. Bull. 11: 25. 1898. Reed-grass.

C. Lapponica A. GRAY, Proc. Am. Acad. **6**: 78. 1862. In part.

Along north shore of Lake Superior.

Herb.: F. F. Wood, St. Louis and Cook counties. Both specimens in the U. S. Nat. Herbarium.

Calamagrostis langsdorfi (LINK) TRIN. Unifl. 225. *pl. 4. f. 10.* 1824. Reed-grass, Blue-joint.

Near Lake Superior.

Herb.: T. S. Roberts, Bailey 519, Agate Bay.

Calamagrostis canadensis (MICHX.) BEAUV. Agrost. 157. 1812. Blue-joint, Reed grass.

Deyeuxia canadensis MUNRO; Hook. f., Trans. Linn. Soc. **23**: 345.

Moist soil throughout, common.

Herb.: Many collections.

Calamagrostis macouniana VASEY, Monog. Grasses U. S., Contr. U. S. Nat. Herb. **3**: 81. 1892. Macoun's reed-grass.

Rare northwest.

Herb.: Ballard, Cass county.

Calamagrostis neglecta (EHRH.) GAERTN.; Gaertn., Mey., und Scherb. Fl. Wetteran, **1**: 94. 1799. Narrow reed-grass.

Deyeuxia neglecta KUNTH. Enum. **1**: 76. 1833.

In moist soil throughout.

Herb.: Ballard 925 and 1032, Nicollet county: Sheldon 331 and 481, Blue Earth county.

Calamagrostis inexpansa A. GRAY, Gram. et Cyp. **1**: No. 20. 1834. Bog reed-grass.

Calamagrostis confinis A. GRAY, Man. Ed. **2**: 547. 1856. Not Nutt.

Herb.: Sandberg, no locality, 1891 (collection reported by Kearney); Ballard, Nicollet county?

Calamagrostis hyperborea elongata Kearney, U. S. Dept. Agric., Div. Agrost. Bull. 11: 40. 1898. Northern reed grass.

In moist soil throughout.

Herb.: Sheldon 3615, 3788, Otter Tail county; Foote, Jarvis, Ramsey county; Ballard 582, Scott county; Campbell, St. Cloud.

Calamagrostis cinnoides (MUHL.) BART. Comp. Fl. Phila. **1**: 45. 1818.

Calamagrostis nuttalliana STEUD. Syn. Pl. Gram. 190. 1855.

Reported from Minnesota but probably does not occur here.

Ammophila arenaria (L.) LINK, Hort. Berol. **1**: 105. 1827. Sea sand-weed.

Ammophila arundinacea HOST, Gram. Austr. **4**: 24. 1809.

Reported as occurring along the south shore of Lake Superior and probably along the north shore. There are no specimens from Minnesota to verify this report.

Calamovilfa longifolia (HOOK.) HACK. True Grasses, 113. 1890. Long-leaved reed-grass.

Calamagrostis longifolia HOOK. Fl. Bor Am. **2**: 241. 1840.

Common on sandy soil throughout.

Herb.: Many collections.

Deschampsia cæspitosa (L.) BEAUV. Agrost. 160. *pl. 18. f. 3.* 1812. Tufted hair-grass.

Northern part of state, frequent.

Herb.: Sandberg, Thomson; Wood, Grand Marais; Cheney 22, Hunter's Island; Bailey 424, Vermilion lake.

Trisetum subspicatum (L.) BEAUV. Agrost. False oats.

On rocks, north shore of Lake Superior.

Herb.: Bailey 490, Agate bay; Wood, Grand Marais; Sandberg, Two Harbors.

Avena striata MICHX. Fl. Bor. Am. 1: 73. 1803. Purple oats.

Frequent in woods north.

Herb.: Ballard 1230, Anderson, 406; Cass county; Sandberg, Washington county; Aiton, Lake Itasca; Sheldon 2736, Milaca; Sandberg 101, N. P. Junction.

Avena fatua L. Sp. Pl. 80. 1753. Wild oats.

Common in cultivated and waste ground throughout. Much more widely distributed than the number of herbarium specimens would indicate.

Herb.: Moyer, Chippewa county; Ballard, 836, Waconia.

Arrhenatherum elatius (L.) BEAUV.; M. & R. Deutsch. Fl. 1: 546. 1823. Oat-grass.

Adventive near the Twin Cities and perhaps elsewhere in the state.

Herb.: Sandsten, Ramsey county.

Danthonia spicata (L.) BEAUV.; R. & S. Syst. 2: 690. 1817. Wild oat-grass.

Common throughout in dry soil.

Herb.: Ballard, Nicollet and Cass counties; Sandberg, Carlton and Douglas counties; Aiton, Lake Itasca; Wood, no locality; Sheldon 2833, Kanabec county; Rosendahl 514, Spring Grove.

Spartina cynosuroides (L.) WILLD. Enum. 80. 1809. Tall marsh-grass, Fresh-water cord-grass.

Common in wet places throughout.

Herb.: Numerous collections.

Spartina gracilis TRIN. Agrost. 1: 88. 1840. Inland cord-grass.

Rare in alkaline soil southwest.

Herb.: Menzel, Pipestone, Aug., 1894.

Schedonnardus paniculatus (NUTT.) TRELEASE, Branner & Coville, Rep. Geol. Surv. Ark. **1888**: Part 4, 236. 1891. Schedonnardus.

Rare southwest.

Herb.: Menzel, Pipestone, July, 1895.

Bouteloua hirsuta LAG. Var. Cienc. y Litter. 2: Part 4, 141. 1805. Hairy mesquite-grass.

Common in dry soil throughout.

Herb.: Numerous specimens.

Bouteloua oligostachya (NUTT.) TORR.; A. Gray, Man. Ed. 2, 553. 1856. Mesquite-grass, Grama-grass.

Dry soil throughout; common west.

Herb.: Collections not so numerous as those of *Bouteloua hirsuta* Lag.

Atheropogon curtipendulus (MICHX.) FOURN. Mex. Pl. En. Gram. 138. Racemed grama-grass.

Bouteloua curtipendula (MICHX.) TORR. Emory's Rep. 153. 1848.

Bouteloua racemosa LAG. Var. Cienc. y Litter. **2**: Part 4, 141. 1805.

Common in dry soil throughout.

Herb.: Numerous collections.

Beckmannia erucæformis (L.) HOST, Gram. Austr. 3: 5: 1805. Beckmannia.

Common throughout the prairie region.

Herb.: Numerous collections from western Minnesota.

Bulbilis dactyloides (NUTT.) RAF.; Kuntze, Rev. Gen. Pl. 763. 1891. Buffalo grass.

Buchloe dactyloides ENGELM. Trans. St. Louis Acad. **1**: 432. 1859.

Rare on dry prairies southwest.

Herb.: Leiberg 94, Pipestone quarry.

Phragmites phragmites (L.) KARST. Deutsch. Fl. 379. 1880–1883. Corn grass, Reed.

Phragmites communis TRIN. Fund. Agrost. 134. 1820.

Common in wet soil throughout.

Herb.: MacMillan and Skinner 394, Crookston; MacMillan and Sheldon 3, Brainerd; Sandberg, Hennepin county; Taylor 222, Janesville, 1019, Glenwood; Wheeler 1142, Luverne.

Eragrostis capillaris (L.) NEES, Agrost. Bras. 505. 1829. Capillary eragrostis.

Reported from Minnesota by Upham but probably does not occur in our range.

Eragrostis frankii STEUD. Syn. Pl. Gram. 273. 1855. Frank's eragrostis.

Reported from Minnesota. There are no specimens in the University herbarium to verify the report.

Eragrostis pilosa (L.) BEAUV. Agrost. 162. 1812. Tufted eragrostis.

The report of this species from Minnesota may be correct but there are no specimens known to verify it.

Eragrostis purshii SCHRAD. Linnæa, **12**: 451. 1838. Pursh's eragrostis.

Common in dry soil throughout.

Herb.: Numerous collections.

Eragrostis major HOST, Gram. Austr. **4**: 14. *pl. 24.* 1809. Strong-scented eragrostis.

Eragrostis poæoides megastachya A. Gray, Man. Ed. 5, 631. 1867.

Waste and cultivated ground throughout.

Herb.: Numerous specimens.

Eragrostis pectinacea (MICHX.) STEUD. Syn. Pl. Gram. 272. 1855. Purple eragrostis.

In dry soil south.

Herb.: Sandberg, Oestlund, Sheldon, Aiton, Hennepin county; Ballard 638, Chaska; Sandberg, Redwing.

Eragrostis refracta (MUHL.) SCRIBN. Mem. Torr. Club, **5**: 49. 1894. Meadow eragrostis.

Eragrostis campestris TRIN. Bull. Acad. Sci. St. Petersb. **1**: 70. 1836.

Reported in Minnesota Botanical Studies, **1**: 67, 1894, as adventive at St. Anthony Park. There are no specimens in the University herbarium.

Eragrostis hypnoides (LAM.) B.S.P. Prel. Cat. N. Y. 69. 1888. Creeping eragrostis.

Eragrostis reptans NEES, Agrost. Bras. 514. 1829.

River and lake shores throughout.

Herb.: Numerous specimens.

Eatonia obtusata (MICHX.) A. GRAY, Man. Ed. 2, 558. 1856. Blunt-scaled eatonia.

In dry soil throughout. Very often confused with *Koeleria cristata* (L.) Pers. by collectors.

Herb.: Numerous collections.

Eatonia pennsylvanica (DC.) A. GRAY, Man. Ed. 2, 558. 1856. Pennsylvania eatonia.

Infrequent throughout.

Herb.: Rosendahl 534, Spring Grove; Ballard 325, Belle Plain; Taylor 658, Blue Earth county; Bailey, 32, Vermilion Lake.

Koeleria cristata (L.) PERS. Syn. 1: 97. 1805. Koeleria.

One of the most common grasses, in dry soil throughout.

Herb.: Numerous collections.

Melica diffusa PURSH, Fl. Am. Sept. 77. 1814. Tall melic grass.

Rare southeast. Not previously reported from Minnesota.

Herb.: Rosendahl, Spring Grove.

Melica mutica WALT. Fl. Car. 78. 1788. Narrow melic grass.

Rare southeast. Collected by L. H. Pammel in Houston county in 1898. This is the only collection known from this state.

Korycarpus diandrus (MICHX.) KUNTZE, Rev. Gen. Pl. 772. 1891. American korycarpus.

Diarrhena americana BEAUV. Agrost. 142. 1812.

Reported from Sherburne county but probably does not extend so far north as Minnesota.

Distichlis spicata (L.) GREENE, Bull. Cal. Acad. 2: 415. 1887. Marsh spike-grass.

A collection by Professor MacMillan from Renville county is reported in the Minnesota Botanical Studies, 1: 68, 1894. There is no specimen from this collection in the University herbarium.

Dactylis glomerata L. Sp. Pl. 71. 1753. Orchard grass.

Escaped from cultivation throughout.

Herb.: Skinner, Heron lake; Wheeler 1253, St. Anthony Park; Aiton, Hennepin county; C. A. Sylvester, Madelia.

Poa annua L. Sp. Pl. 68. 1753. Annual meadow-grass.

Waste places probably throughout.

Herb.: Kassube 191, Minneapolis.

Poa nemoralis L. Sp. Pl. 69. 1753. Wood meadow-grass.

Poa cæsia strictior A. GRAY, Man. Ed. 5, 629. 1867.

Throughout. Often confused with *Poa flava* L. by collectors.

Herb.: Sandberg, Red Wing; Sheldon 2501, Mille Lacs Indian Reservation,

Poa flava L. Sp. Pl. 68. 1753. False redtop, Fowl meadow-grass.

Poa serotina EHRB. Beitr. **6**: 83. 1791.

Poa palustris L. Syst. 874. 1759.

Common throughout.

Herb.: Specimens from thirty-four collections in the University herbarium, many of which have been previously determined and reported by the collectors as *Agrostis alba* L.

Poa pratensis L. Sp. Pl. 67. 1753. Kentucky blue-grass, June grass.

Abundant throughout.

Herb.: Numerous specimens.

Poa glauca VAHL, Fl. Dan. *pl. 964.* 1790. Glaucous spear-grass.

Poa cæsia J. E. SMITH, Eng. Bot. *pl. 1719.* 1807.

Reported by Upham but probably does not occur in Minnesota.

Poa debilis TORR. Fl. N. Y. **2**: 459. 1843. Weak spear-grass.

In woods, north.

Herb.: Aiton, Lake Itasca; Sheldon 2608, Mille Lacs Reservation.

Poa sylvestris A. GRAY, Man. 596. 1848. Sylvan spear-grass.

Reported by Upham but probably does not reach so far north as Minnesota.

Poa alsodes A. GRAY, Man. Ed. 2, 562. 1856. Grove meadow-grass.

Rare east.

Herb.: Sandberg, Thomson.

Poa wolfii SCRIBN. Bull. Torr. Club, **21**: 228. 1894. Wolf's meadow-grass.

Rare southeast. Not previously reported from Minnesota.

Herb.: Rosendahl 285, Spring Grove.

Poa pseudopratensis SCRIBN. & RYDB. in Br. & Br. Illus. Fl. **1**: 204. 1896. Prairie meadow-grass.

Western prairies.

Herb.: Moyer, Montevideo. (Determined at the U. S. Dept. of Agric.)

Poa alpina L. Sp. Pl. 67. 1753. Alpine spear-grass.
North shore of Lake Superior.
Herb.: Sandberg, Two Harbors?

Poa compressa L. Sp. Pl. 69. 1753. Flat-stemmed meadow-grass.
Waste and cultivated grounds throughout.
Herb.: Many specimens.

Scolochloa festucacea (WILLD.) LINK, Hort. Berol. **1**: 137. 1827. Fescue scolochloa.

No previous report based on authentic Minnesota collection. The report in Upham's catalog is based entirely on Cratty's Iowa collection.

Herb.: Sheldon 448, Blue Earth county; Ballard 937, Nicollet county; MacMillan and Sheldon 1452, Sandy Beach.

Graphephorum melicoideum (MICHX.) BEAUV. Agrost. 164. *pl. 15. f. 8.* 1812. Graphephorum.

No authentic collection known from Minnesota.

MacMillan and Sheldon's collection number 1452 from Sandy Beach, Lake of the Woods, reported in the Minnesota Botanical Studies, **1**: 964 and 975, as this species is *Scolochloa festucacea* (Willd.) Link.

Panicularia canadensis (MICHX.) KUNTZE, Rev. Gen. Pl. 783. 1891. Rattle-snake grass.
Glyceria canadensis TRIN. Mem. Acad. St. Petersb. (VI.) **1**: 366. 1831.
Common in wet places north, less frequent south.
Herb.: Many collections.

Panicularia torreyana (SPRENG.) MERRILL, Rhodora, **4**: 146. 1902.
Glyceria elongata TRIN. Gram. Suppl. **58**: 1836.

The report in Upham's catalog on this species is doubtful. There are no known specimens from Minnesota.

Panicularia nervata (WILLD.) KUNTZE, Rev. Gen. Pl. 783. 1891. Nerved manna-grass.
Glyceria nervata TRIN. Mem. Acad. St. Petersb. (VI.) **1**: 365. 1831.
In wet places throughout.
Herb.: Numerous specimens.

Panicularia americana (TORR.) MACM. Met. Minn. Val. 81. 1892. Reed meadow-grass.

Glyceria grandis S. WATS. in A. Gray, Man. Ed. 6: 667. 1890.

Wet places throughout.

Herb.: Numerous collections.

Panicularia fluitans (L.) KUNTZE, Rev. Gen. Pl. 782. 1891. Floating manna-grass.

Glyceria fluitans R. BR. Prodr. Fl. Nov. Holl. 1: 179. 1810.

No authentic specimens known from Minnesota.

All collections from Minnesota in the University herbarium under this name are *Panicularia borealis* Nash.

Panicularia borealis NASH, Bull. Torr. Club, 24: 348. 1897. Slender manna-grass.

Glyceria fluitans minor VASEY; L. S. Cheney in Trans. Wis. Acad. Sci. 9: 247. No description.

In wet places throughout.

Herb.: Many collections.

Puccinellia airoides (NUTT.) WATS. & COULT. in A. Gray, Man. Ed. 6, 668. 1890. Slender meadow-grass.

Saline soil, Red River valley.

Herb.: Ballard 2528, Fergus Falls; MacMillan and Sheldon, Lake of the Woods.

Festuca octoflora WALT. Fl. Car. 81. 1788. Slender fescue-grass.

Festuca tenella WILLD. Enum. 1: 113. 1809.

Dry sandy soil throughout.

Herb.: Many collections from southern half of state.

Festuca rubra L. Sp. Pl. 74. 1753. Red fescue-grass.

Reported from Minnesota and possibly occurs along the northern boundary.

Festuca ovina L. Sp. Pl. 73. 1753. Sheep fescue-grass.

Probably occurs throughout the state.

Herb.: Sandberg, Thomson; Bailey 489, Agate bay; Campbell, St. Cloud; Bailey 450, Vermilion lake; Sheldon 2669, Aitkin county; Sandsten, Ramsey county; Chapman, Hennepin county.

Festuca elatior L. Sp. Pl. 75. 1753. Meadow fescue-grass.

Fields and cultivated grounds throughout.

Herb.: Rosendahl, Spring Grove; Wheeler, Hennepin county; Skinner, Heron lake.

Festuca shortii KUNTH.; Wood, Class-book, 794. 1861. Short's fescue-grass.

Rare southeast, not previously reported from Minnesota.

Herb.: Sandberg 43, Goodhue county.

Festuca nutans WILLD. Enum. 1: 116. 1809. Nodding fescue-grass.

In woods throughout.

Herb.: Many collections.

Bromus inermis LEYSS. Fl. Ital. 16. 1761. Hungarian brome-grass.

Recently introduced into the state as a forage plant and has escaped from cultivation in some places.

Bromus ciliatus L. Sp. Pl. 76. 1753. Fringed brome-grass.

In woods throughout.

Herb.: Numerous collections.

Bromus purgans L. Sp. Pl. 176. 1753. Wood chess.

In woods throughout.

Herb.: Numerous collections.

Bromus purgans latiglumis (SCRIBN.) SHEAR, U. S. Dept. Agric., Div. Agrost. Bull. 23: 40. 1900. Broad-glumed wood chess.

With the species.

Herb.: Ballard 1161, Goodhue county. (Determined by C. L. Shear.)

Bromus kalmii A. GRAY, Man. 600. 1848. Hairy chess.

Common throughout.

Herb.: Numerous collections.

Bromus secalinus L. Sp. Pl. 76. 1753. Chess, Cheat.

Fields and waste places. A common weed in grain fields south.

Herb.: Lyon 184, Houston county; Frost 218, Willmar; Holzinger 44, Winona; Ballard 221, Scott county; Sheldon 661, Waseca.

Bromus racemosus L. Sp. Pl. Ed. 2, 114. 1762. Upright chess.

Previously reported by Upham and may occur here. It may however have been confused with *Bromus secalinus* L., from which it is with difficulty distinguished.

Lolium temulentum L. Sp. Pl. 83. 1753. Darnel.

Locally adventive.

Herb.: Leiberg, Mankato, 1883.

Agropyron richardsoni SCHRAD. in Linnæa, **12**: 467. 1838. Awned wheat-grass.

Agropyron caninum violascens RAMALEY, Minn. Bot. Stud. **1**: 107. 1894.

Agropyron violaceum caninoides RAMALEY, Minn. Bot. Stud. **1**: 107. 1894.

Most collectors have probably confused this with *Agropyron caninum* (L.) R. & S.

Herb.: Campbell 77, St. Cloud; Sheldon 3298, Mille Lacs county; MacMillan and Sheldon 84, Brainerd; Ballard 1726, Cass county; Skinner 203, Heron lake; Wheeler 1223, Ramsey county.

Agropyron caninum (L.) R. & S. Syst. **2**: 756. 1817. Nodding wheat-grass.

Frequently reported from Minnesota. No collections from this state in the University herbarium.

Agropyron tenerum VASEY, Coult. Bot. Gaz. **10**: 258. 1885. Slender wheat-grass.

Common throughout.

Herb.: Ballard 2569, St. Vincent; MacMillan and Skinner 304, 335, Crookston; Sheldon 979, Sleepy Eye, 3299 Mille Lacs county; MacMillan and Sheldon 82, Brainerd; Wheeler, St. Anthony Park.

Agropyron violaceum (HORNEM.) VASEY, Spec. Rep. U. S. Dept. Agric. 63: 45. 1883. Purplish wheat-grass.

Rare north.

Herb.: Bailey 494, Agate Bay.

Agropyron occidentale SCRIBN. U. S. Dept. Agric., Div. Agrost. Cir. 27: 9. 1900. Western quack-grass.

Agropyron repens glaucum (DESF.) SCRIB. Mem. Torr. Club, **5**: 57. 1894.

Agropyron spicatum SCRIBN. and SM. U. S. Dept. Agric., Div. Agrost. Bull. 4: 33. 1897.

Fields and waste places throughout. The most common quack or couch-grass in the state.

Herb.: Numerous specimens.

Agropyron dasystachyum (HOOK.) VASEY, Spec. Rep. U. S. Dept. Agric. 63: 45. 1883. Hairy-glumed wheat-grass.

Reported from Minnesota. No authentic collections known.

Agropyron pseudorepens SCRIBN. and SM. U. S. Dept. Agric., Div. Agrost. Bull. 4: 34. 1897. False quack-grass.

Throughout.

Herb.: Rosendahl 628, Spring Grove; Moyer, Montevideo; Sheldon 2505, Mille Lacs Reservation; Bailey 511, Agate Bay; Skinner 105, Heron lake.

Agropyron repens (L.) BEAUV. Agrost. 146. 1812. Quack-grass.

Commonly adventive east.

Herb.: Rosendahl 446, Spring Grove; Sheldon 2837, Kanabec county; Ramaley 217, Ramsey county; Sandberg 37, Hennepin county; Bailey 42, Vermilion lake.

Hordeum nodosum L. Sp. Pl. Ed. 2, 126. 1762. Meadow barley.

All reports of this species probably refer to the next.

Hordeum pusillum NUTT. Gen. 1: 87. 1818. Little barley.

Dry soil south.

Herb.: Menzel, Pipestone.

Hordeum jubatum L. Sp. Pl. 85. 1753. Squirrel-tail grass.

Common in dry soil throughout.

Herb.: Numerous collections.

Sitanion elymoides RAF. Journ. Phys. 89: 103. 1819. Long-bristled wild rye.

Elymus sitanion SCHULTES, Mant. 2: 426. 1824.

Reported from southwestern Minnesota. No specimens known to verify report.

Elymus striatus WILLD. Sp. Pl. 1: 470. 1797. Slender wild rye.

Common throughout.

Herb.: Wheeler 1067, Luverne; Aiton, Hennepin county; Ballard 1005, Nicollet county; Campbell 129, Stearns county.

Elymus arkansanus SCRIBN. & BALL, U. S. Dept. Agric., Div. Agrost. Bull. 24: 45. 1900. Arkansas wild rye.

Dry soil south. Previously confused with *Elymus striatus*. Willd.

Herb.: Sheldon 842, 976½. Sleepy eye.

Elymus virginicus L. Sp. Pl. 84. 1753. Stout wild rye.

Common throughout.

Herb.: Aiton, Hennepin county; Wheeler 418, Houston county; Sandberg, Red Wing; Ballard 2629, St. Vincent; Sheldon 3690, Fergus Falls; Oestlund, Minneapolis; MacMillan and Skinner 235, Crookston.

Elymus virginicus minor VASEY, Contrib. U. S. Nat. Herb. **2**: 550. May, 1894.

Elymus virginicus jejunus RAMALEY, Minn. Bot. Stud. **1**: 114. June, 1894.

Herb.: Sheldon 1375, Lake Benton (Ramaley's type); Bailey 265, St. Louis river.

Elymus diversiglumis SCRIBN. & BALL, U. S. Dept. Agric., Div. Agrost. Bull. 24: 48. 1900.

Probably throughout. Not previously reported from Minnesota.

Herb.: Ballard, Scott county; Anderson, Cass county; MacMillan and Skinner 107, 267, Crookston; Campbell 130, Rockville; Wheeler Wyoming, 1224, St. Anthony Park.

Elymus canadensis L. Sp. Pl. 83. 1753. Nodding wild rye.

Common throughout.

Herb.: Numerous collections.

Elymus crescendus (RAMALEY) n. comb. Robust nodding wild rye.

Elymus canadensis L. forma *crescendus* Ramaley, Minn. Bot. Studies **1**: 114. 1894.

Elymus robustus SCRIBN. and SM. U. S. Dept. Agric., Div. Agrost. Bull. 4: 37. 1897.

Common throughout.

Herb.: Sheldon 1120, Springfield (type); Sandberg, Aiton, Anderson, Hennepin county; MacMillan and Sheldon 1120, Oak Point; Sandsten, Ramsey county; Menzel, Pipestone.

Elymus brachystachys SCRIBN. & BALL, U. S. Dept. Agric., Div. Agrost. Bull. 24: 47. 1900. Nodding wild rye.

Rare south.

Herb.: Lewis Foote, Worthington ?

Elymus glaucus BUCKL. Proc. Acad. Phila. **1862**: 99. 1862. Smooth wild rye.

Elymus sibiricus L. Sp. Pl. 83. 1753. In part.

Reported in Upham's catalog. No authentic collections known from this state.

Elymus macouni VASEY, Bull. Torr. Club, **13**: 119. 1886. Macoun's wild rye.

Infrequent in dry soil throughout.

Herb.: Ballard 2570, St. Vincent; Skinner 223, Heron lake; Wheeler 1254, St. Anthony Park.

Elymus arenarius L. Sp. Pl. 83. 1753. Downy wild rye.

Reported from the north shore of Lake Superior. No authentic collection known from Minnesota.

Hystrix hystrix (L.) MILLSP. Fl. W. Va. 474. 1892. Bottle-brush grass.

Asprella hystrix WILLD. Enum. 132. 1809.

Common in woods throughout.

Herb.: Numerous collections.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.
CONWAY MACMILLAN, *State Botanist*

Minnesota Botanical Studies

Contents

Third Series

Part II - - July 3, 1903

MINNEAPOLIS, MINN.
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XII. THE MOSS FLORA OF THE UPPER MINNESOTA RIVER.

JOHN M. HOLZINGER.

The material on which this report is based was collected under the auspices of the Minnesota Botanical Survey, on an exploring trip during June and the first half of July, 1901, mostly through Kandiyohi, Chippewa, Lac qui Parle and Big Stone counties.

Four days were spent in exploring portions of Kandiyohi county with its numerous glacial lakes (June 9–13). Collections were made on the shores of Green lake and Diamond lake, in the vicinity of the village of Kandiyohi.

The main valley of the Minnesota river was touched at Granite Falls, where part of two days was spent on the outward trip (June 13, 14). This region was however more fully explored on the return trip (July 10–15).

The next collecting center was Montevideo, in Chippewa county (June 15–21). Though lying on the Chippewa river, a short distance above its confluence with the Minnesota, this base offered excellent opportunities for studying the main valley, which is here studded by numerous low outcrops of archæan granites. Except in the broad valley of the river, these oldest rock formations are, in this part of the state, covered deep with moraines and glacial drift. This overlies them 200 feet and more, forming the bluff slopes of the general valley. Two small bodies of water, mere pools but by courtesy called Carlton lake and Cedar lake having no connection with the main stream, lie nestled among these outcrops near Montevideo, in the main valley. The borders of these ponds afforded especially profitable collecting grounds.

At this point the securing and care of material was greatly facilitated by the many courtesies of Judge Lycurgus R. Moyer, resident at Montevideo, and it seems proper in this connection to make acknowledgment of his assistance. From here on

Mr. Moyer accompanied the writer, assisting generously in all possible ways to make the expedition a success. The fact that he had traversed the region some years before in the capacity of a surveyor rendered him the more valuable both as guide and adviser.

Another member of the little exploring party from this point on was Mr. John Anderson, science teacher at the high school in Dubuque, Iowa, who came to study the flowering plants of the region on his own account, and whose informal assistance made possible a more effective survey by the writer.

The region around the lower end of Big Stone lake, from Ortonville to several miles down the valley, was explored from June 22 to 26. Then the party made a trip on a farmer's wagon around Big Stone lake, going up on the west, and returning on the east side. Here Mr. John Conrad, who acted as driver and guide, rendered valuable assistance in leading the party to the most productive collecting grounds accessible along the lake. Unfortunately, by the deplorable shortsightedness of the farmers whose lands abut on the lake, this fine sheet of water, some forty miles long, is almost completely fenced in, making it difficult and in places impossible of approach. At the lower end the public highway lies for a few miles along the shore of the lake. Here we passed through Simpson park, the summer camping ground for the Chautauqua Assembly (June 26). From here on we saw little of the lake till late in the day, when we reached Hartford, twenty miles above on the bank of the lake. Hartford is not a village, but is the site of a recent attempt at establishing one, the only evidence being the burnt-out ruins of a hotel. Here the wooded slope, a spring-fed rivulet that reaches a short distance back into a willow-bordered swamp, and several broad areas of shaded seepage springs which seem to be very abundant on both banks of the lake, furnished excellent collecting ground (June 26, 27).

Camp was broken next day in time to reach Brown's Valley at the upper end of the lake before nightfall. The weather being showery, only a short stop was made here (June 28). Camp was broken between showers, and an attempt made to reach Foster, on the east bank of the lake, opposite Hartford. Here we collected from daybreak till toward noon next day (June 29), breaking camp early enough to reach Ortonville before night that day.

The next week (till July 8) was spent in further exploration below Ortonville. On the return trip stops were made at Montevideo (July 8–10), and at Granite Falls (July 10–15), with such good results as the systematic list of species shows.

The region of the upper Minnesota river thus explored is a part of the area treated by Professor C. W. Hall in the Bulletin of the United States Geological Survey, No. 157 (1899). The prairies back of the general valley are made up entirely of morainic and drift materials. The valley is from two to four miles and more wide; and the bordering bluffs are from 150 to 200 feet high. Scattered over this valley, in numerous clusters, are the ice-rounded, or frequently jagged outcrops of gneisses and granites mentioned above. In and out among these the present river winds. Not so in the recently past geological time, the time of great Lake Agassiz, now shrunken to a mere shadow of its former self, into Lake Winnipeg and the cluster of lakes surrounding it. At that time, the Red river of the North, instead of flowing into Lake Winnipeg and contributing its waters to the Hudson Bay system, was an outlet from Lake Agassiz in the opposite direction, through the present Minnesota valley, into the Mississippi system. That ancient river, in the height of its use as a drainage channel for these northern waters, must have appeared more like a great estuary, stretching across what is now southern Minnesota, than like an inland river. And, judging from the stately sweep of its valley, it must, in its time, have received the present Mississippi as a secondary stream of comparatively small volume. That this stream has had a great influence upon the distribution of organisms, notably of plants, along its course, especially during interglacial and postglacial time, as the ice cap receded, can hardly be doubted. I take it that the occurrence in this great valley, to which of course we must add the Mississippi valley proper, of such Rocky Mountain species as the two North American *Coscinodons*, of *Grimmia brandegei*, of *Ceratodon conicus*, and others, was made possible through that ancient channel. Like stranded strangers, these plants persist among the archæan and silurian rocks of these great rivers, far sundered from their kindred by a climatic barrier at present impassable for them. For, the western border of our state, including the region explored, approaches that doubtful strip across the great North American farm lands between the 95th and 100th meridians approximately,

to the east of which lie the great prairies with rainfall sufficient to insure perennial fertility, while to the west there is what the early explorers called the Great American Desert, stretching to the base of the Rocky Mountains, suffering from a deficiency of rainfall.

This climatic condition, approaching semi-aridity, appears to have come on gradually, if we may judge from the considerable number of stunted, starved and sterile species that were collected, several of which it has not been possible to determine satisfactorily. Of the ninety-six species worked out forty-four are new to the state, that is, have not been reported before. Of these, six are new species.

Finally, grateful acknowledgment is due to the following persons: to Dr. A. J. Grout for naming the species of *Brachythecium* and *Eurhynchium;* to Dr. G. N. Best for naming the species of *Anomodon*, *Leskea* and *Thuidium;* to Mrs. E. G. Britton for naming species of *Orthotrichum;* to Prof. L. S. Cheney for naming a number of species, principally *Amblystegium;* to Messieurs Cardot and Thériot for naming the species of *Bryum* and of several other genera; to M. F. Renauld for naming species of *Hypnum*, principally of the section *Harpidium*, and to Dr. N. Bryhn for naming the species of *Philonotis*.

Following is the list of additions to the moss flora of Minnesota:

Amblystegium brachyphyllum CARD. ET THER., n. sp.
Amblystegium brevipes CARD. ET THER., n. sp.
Amblystegium compactum (C. M.) AUST.
Amblystegium irriguum (WILS.) B. S.
Amblystegium riparium trichopodium BRID.
Archidium ohioense SCH.
Astomum crispum HPE.
Brachythecium cyrtophyllum KINDB.
Brachythecium rivulare B. S,
Bryum capillare flaccidum BR. EUR.
Bryum holzingeri CARD. ET THER., n. sp.
Bryum meesioides KINDB.
Bryum minnesotense CARD. ET THER., n. sp.
Bryum obconicum HSCH.
Bryum pseudotriquetrum SCHW.
Catharinæa macmillani HOLZ.
Ceratodon conicus HPE.

Encalypta rhabdocarpa leptodon (Br.) Sch.
Eurhynchium strigosum fallax Ren. et Card.
Fissidens viridulus (Swartz) Wahlenb.
Fissidens viridulus lylei (Wahlenb.), Dixon and Jameson.
Fontinalis obscura Card. et Ther., n. sp.
Funaria americana Lindb.
Grimmia brandegei Aust.
Grimmia leucophæa Grev.
Hedwigia ciliata viridis Sch.
Hypnum aduncum Hedw.
Hypnum aduncum intermedium Sch.
Hypnum aduncum intermedium, forma *laxa* Sch.
Hypnum aduncum intermedium, forma *laxifolia* Sno.
Hypnum aduncum kneiffii Sch.
Hypnum aduncum tenue Sch.
Hypnum aduncum tenue, forma *amblystegioides* Ren.
Leskea arenicola Best.
Octodiceras julianum (Savi) Brid.
Orthotrichum porteri Aust.
Orthotrichum schimperi Hammar.
Phascum sp.
Philonotis alpicola Jur.
Plagiothecium sullivantiæ Sch.
Pleuridium subulatum B. S.
Pterygoneurum subsessile (Brid.) Jur.
Pyramidula tetragona (Brid.) Brid.
Trichostomum tophaceum Brid.
Webera cruda (L.) Bruch.

SYSTEMATIC LIST OF SPECIES.

1. **Archidium ohioense** Sch.

On the ground, at Granite Falls (June 13–14).

At Ortonville (June 22).

2. **Phascum** sp.

The plants found are not in good condition for specific determination, but doubtless belong to this genus.

On earth, at Ortonville (June 24).

3. **Pleuridium subulatum** B. S.

The plants show the sporadically double lamina in the upper part of the leaf described by Limpricht, in Laubm.

Among grass in small tufts, at Granite Falls (June 13–14).
At Montevideo (June 16).
At Ortonville (June 22).

4. **Astomum crispum** HPE.
On earth, at Montevideo (June 16).

5. **Dicranum bonjeani** DE NOT. (*D. palustre* LA PYL.)
At Cedar lake, near Montevideo (June 18).
Only one large cushion was found.

6. **Fissidens viridulus** (SWARTZ) WAHLENB.
At Ortonville (June 24).
At Foster, on the east shore of Big Stone lake (June 29).
At Granite Falls (July 12).

7. **Fissidens viridulus lylei** (WAHLENB.) DIXON & JAMESON.
Intermediate forms occur here, just as described by Dixon in the Hand-book of British Mosses, p. 120.
On a porous limestone bowlder, in Simpson Park at the south end of Big Stone lake, on the Dakota side (June 26).

8. **Octodiceras julianum** (SAVI) BRID. (*Conomitrium julianum* MONT.)
In water on submerged sticks, at Granite Falls (July 15).

9. **Ceratodon purpureus** BRID.
Very abundant, in large cushions in the depressions of granitic outcrops, at Granite Falls (June 13 and 14).
At Montevideo (June 16).
At Ortonville (June 24).
At Foster, east shore of Big Stone lake (June 29).

10. **Ceratodon conicus** HPE. (Determined by Cardot & Thériot.)
At Montevideo (June 16).

11. **Pterygoneurum subsessile** (BRID.) JUR. (*Pharomitrium subsessile* SCH.)
On the ground, on gravel hills near Ortonville (July 1).

12. **Didymodon rubellus** (HOFFM.) BR. EUR.
In Kandiyohi county (June 9–13).
At Granite Falls (June 14).
At Ortonville (June 24).
At Hartford, on the Dakota shore of Big Stone lake (June 27).
At Foster, on the Minnesota shore of Big Stone lake (June 29).

13. **Trichostomum tophaceum** Brid. (?) Sterile.

On a perpendicular wall of porous limestone dripping with water, at Foster, on the Minnesota shore of Big Stone lake (June 29).

14. **Ditrichum glaucescens** (Hedw.) Hpe.

At Granite Falls (July 12).

15. **Barbula fallax** Hedw.

In Kandiyohi county (June 9–13).
At Granite Falls (June 14).
At Ortonville (June 22).

16. **Barbula mucronifolia** (Brid.) Br. eur.

In Kandiyohi county (June 9–13).
At Granite Falls (June 14).
At Ortonville (June 24).
At Foster, on the east shore of Big Stone lake (June 29).

17. **Barbula ruralis** (L.) Hedw.

At Cedar lake, near Montevideo (June 18).
At Ortonville (June 23).

18. **Barbula unguiculata** (Huds.) Hedw.

On the ground, in Kandiyohi county (June 9–13).
At Foster (June 29).

19. **Grimmia brandegei** Aust.

I am persuaded that this plant is specifically distinct from the European *G. plagiopodia*, and should not be referred to it as a variety, as is done in Lesq. and James' Manual, p. 138. And Austin's name has the right of way over the varietal name imposed by Lesquereux and James. This Minnesota plant compares perfectly with one collected by Professor C. F. Baker, near Durango, Colo., the region of the type locality of *G. brandegei*.

Between Foster and Ortonville, on a calcareous rock along the high banks of Big Stone lake (June 29).

20. **Grimmia apocarpa** Hedw.

On rocks.
At Ortonville (June 22).
At Foster, a small form (June 29).
At Montevideo, also a small form (July 7).

21. **Grimmia leucophæa** GREV.

Abundant, on rocks, at Granite Falls (June 13, 14).
At Carlton lake, near Montevideo (July 10).
Near Ortonville (June 30).

22. **Grimmia pennsylvanica** SCHW.

On rocks, at Granite Falls (June 13, 14).
At Cedar lake, near Montevideo (June 18 and July 8).

The plants from Cedar lake show hardly any hair points, but agree otherwise with this species.

23. **Hedwigia ciliata viridis** SCH.

On rocks.
At Granite Falls (June 14).
At Ortonville (June 23).
At Carlton lake and Cedar lake near Montevideo (July 2–10).

Forms approaching the species are found, but *Hedwigia ciliata* proper seems rare in the Upper Minnesota valley.

24. **Orthotrichum anomalum** HEDW.

On rocks at Granite Falls (June 13, 14).
At Cedar lake, near Montevideo (June 18).
This was verified by Mrs. E. G. Britton.

25. **Orthotrichum porteri** AUST.

On rocks associated with *O. anomalum*. (Determined by Mrs. E. G. Britton.)
At Cedar lake, near Montevideo (June 18).
At Granite Falls (July 14).

26. **Orthotrichum schimperi** HAMM.

On ash and elm trees. (Determined by Mrs. E. G. Britton).
At Ortonville (June 23).
At Hartford, west shore of Big Stone lake (June 27).

27. **Encalypta ciliata** HEDW. On shaded ground.
At Granite Falls (July 13).

28. **Encalypta rhabdocarpa leptodon** (BRUCH) LIMPR.

A form distinct from the species, apparently deserving varietal rank, although Husnot (Muscol. Gall., p. 198) refers to it as "forma *gymnostoma* Jack." Boulay, in Muscinées de la France, p. 313, remarks on this point that "it often happens that in consequence of the extremes of climatic conditions to

which this plant is exposed the peristome is not developed, or remains rudimentary (var. *leptodon*)." This exposure to extremes of climate is doubtless responsible for our Minnesota form.

At Granite Falls (June 14).

29. **Pyramidula tetragona** (Brid) Brid.

Very common in the shallow depressions on the granitic "roches moutonnées," from Granite Falls to Big Stone lake. All the plants collected were badly weathered, and in poor condition. Husnot gives "spring" as the season for this species. But if the plants found grew and matured in the spring of 1901, it seems remarkable that they should become so badly weathered by the middle of June.

At Granite Falls (June 14).
Near Montevideo (June 18).
Near Ortonville (June 24).

30. **Physcomitrium hookeri** Hampe.

On the ground in Kandiyohi county (June 9–13).
Near Montevideo (June 17).
At Foster (June 29).

31. **Physcomitrium turbinatum** C. M.

On the ground, at Granite Falls (June 13–14).
Near Montevideo (June 17; July 8).
At Cedar lake (June 18).
On the shore of Lac qui Parle lake (June 20).
Near Ortonville (July 4).

32. **Funaria americana** Lindb.

On the ground, always in rich, black, sandy soil, in shaded situations, near Ortonville (June 23).

At Granite Falls (July 13).

See also the Bryologist, Jan., 1902, p. 7.

33. **Funaria hygrometrica** (L.) Sibth.

On the ground, in Kandiyohi county (June 9–13).
At Granite Falls (June 14).
Near Montevideo (June 20).
At Simpson Park, on the Dakota side of Big Stone lake (June 26).
At Hartford, on the west shore of Big Stone lake (June 27).

34. **Bartramia pomiformis** (L. ex p.) HEDW.
At Granite Falls (July 14).

35. **Philonotis alpicola** JUR. (Determined by Dr. N. Bryhn.)
The plants formed a dense sod on a granitic ledge where moisture filtered through a crevice. Near Ortonville (June 24).

36. **Leptobryum pyriforme** (L.) SCH.
Common in Kandiyohi county (June 9–13).
At Hartford (June 27).
At Foster (June 29).

37. **Webera albicans** (WAHLENB.) SCH. (*Mniobryum albicans* (WAHLENB.) LIMPR. in Laubm., II., p. 277.)
On moist earth, at Hartford (June 27).
At Brown's Valley (June 28).
At Foster (June 29).

38. **Webera cruda** (L.) BRUCH.
On the ground, near Ortonville (June 22).

39. **Webera nutans** (SCHREB.) HEDW.
(See Limpr. Laubm., II., p. 249.)
Near Ortonville (June 25).

40. **Bryum argenteum** L.
In Kandiyohi county (June 9–13).
At Granite Falls (June 13, 14).
At Hartford (June 27).

41. **Bryum capillare flaccidum** BR. EUR.
On the shady side of granite rock, on scant but well moistened soil. The alga-like fragile threads, considered to be vegetative gemmæ, and found on the European specimens, are found in great abundance on the Minnesota plants. See Limpr. Laubm., II., p. 377. Also Correns, Unters. ü. d. Verm. d. Laubm., p. 185, also the Bryologist for Jan., 1902, p. 9.
At Granite Falls (June 13, 14).
At Cedar lake (June 18).

42. **Bryum pendulum** (HORNSCH.) SCH.
On the ground, at Cedar lake, near Montevideo (June 18).
Near Ortonville (June 22–26).
At Granite Falls (July 10).

43. **Bryum meesioides** KINDB.
On moist, shaded ground, at Hartford, on the west shore of Big Stone lake (June 27).
At Foster, on the east shore (June 29).

44. **Bryum obconicum** HRHS.
On shaded ground, in Kandiyohi county (June 9–13).

45. **Bryum pseudotriquetrum** (HEDW. ex p.) SCHW.?
On moist, springy ground.
At Granite Falls (June 13, 14).
At Cedar lake, near Montevideo (June 18).
Near Ortonville (June 22).

46. **Bryum torquescens** BR. EUR.
On shaded ground, at Granite Falls (June 13, 14).

47. **Bryum minnesotense** CARD. ET THÉR., sp. nov. (Plate XX., 1.)

Dioicum, dense cæspitosum. Caulis 5–10 millim. altus, erectus, radiculosus, innovationibus numerosis. Folia caulina madida erecto-patentia, sicca appressa, circa 2 millim. longa, 1–1.5 lata, ovato-lanceolata, breviter acuminata, integra, apiceve denticulis nonnullis prædita, nervo excurrente sat longe cuspidata, marginibus e basi usque ad apicem revolutis; folia ramea longiora, longius acuminata, sicca subtorta; cellulis basilaribus hyalinis, elongato-rectangulatis, mediis superioribusque breviter hexagonis, valde chlorophyllosis, marginalibus linearibus, in 4 vel 5 seriebus dispositus, limbum distinctum efformantibus. Capsula in pedicello 2–2.5 centim. longo, basi pro more geniculato, nutans vel subhorizontalis, oblongo-pyriformis, collo elongato attenuato siccitate plicato, operculo conico. Annulus latus. Exostomium *B. penduli*, 0.36 millim. altum, lamellis inferioribus anastomosatis. Endostomium adhærens, membrana dimidiam partem dentium æquante, ciliis non appendiculatis. Sporæ 18–20 μ. Planta mascula ignota.

Differs from *B. pendulum*, by its narrower, longer capsule, provided with longer neck, longer cilia and diœcious inflorescence.
At Granite Falls (June 13, 14).

48. **Bryum holzingeri** CARD. ET THÉR., sp. nov. (Plate XXI., 1.)

Præcedenti valde affine, a quo differt: floribus synoicis, foliis basi angustatis, margine minus longe revoluto, superne plano, acumine longiore apice distinctius denticulato, cellulis mediis circa duplo longioribus, limbo latiore, e 6 vel 7 seriebus cellularum composito, denique capsula etiam longiore et pro longitudine angustiore.

The longer and narrower capsule easily distinguishes this species from *B. pendulum*.

At Cedar lake (June 18).
At Hartford (June 27).
At Foster (June 29).

49. **Bryum roseum** (WEIS.) SCHREB.
In Kandiyohi county (June 9–13).
Near Ortonville (June 22).

50. **Mnium cuspidatum** (L. ex p., SCHREB.) LEYSS.
At Granite Falls (June 13, 14).
Near Ortonville (June 25).
At Hartford (June 27).
Near Browns Valley (June 28).

51. **Aulacomnium palustre** (L.) SCHWAEGR.
At Granite Falls (June 13, 14).

52. **Timmia bavarica cucullata** (Mx.).
On a shady wooded bank.
At Hartford, on the west shore of Big Stone lake (June 27).

53. **Catharinæa macmillani** sp. nov. (Plate XIX.)

Dioica, floribus inventis femineis. Planta simplex, usque ad 2 centim. longa. Folia sicca involuta et circinata, madida erecto-patentia, margine bistratoso e duabus seriebus cellularum constructo dentibus geminis serrato; lamina utraque facie valde papillosa, inferiore etiam dentata; lamellis 7–10 cellulas 8–12 altis, cellula terminali leviter papillosa. Cætera ignota.

This species is at once distinguished by its papillose leaves. It is dedicated to Professor Conway MacMillan, director of the Minnesota Botanical Survey.

On the ground near Ortonville (June 25).

NOTE. — The original spelling of the generic name is *Catharinæa*, not *Catharinea*.

54. **Polytrichum commune** L.
Near Ortonville (June 25), in the shade of a granitic outcrop.

55. **Polytrichum juniperinum** WILLD.
At Granite Falls (June 14).
Near Montevideo (June 17).

56. **Polytrichum piliferum** SCHREB.
At Granite Falls (June 12).
Near Ortonville (June 23).

57. **Fontinalis obscura** CARD. sp. nov. (Plate XXII., 2.)

Planta sat mollis, obscuro- vel atro-viridis, inferne nigricans. Caulis 10–15 centim. longus, flexuosus, basi denudatus, irregu-

lariter divisus pinnatusve, ramis patentibus vel patulis, obtusis vel breviter cuspidatis. Folia sat conferta, caviuscula, mollicula, erecto-patentia, ad apicem caulis et ramorum imbricata, fragilia, sæpe erosa vel effracta, caulina ovato- vel oblongo-lanceolata, obtuse vel acute acuminata, integra, 3–3.5 millim. longa, .9–1.2 lata, ramea angustiora, .6–.85 lata, 2.1–3.5 longa. Cellulæ alares subquadratæ vel oblongæ, parum distinctæ, ceteræ lineares, subflexuosæ, superiores breviores, omnes chlorophyllosæ. Cetera ignota.

Seems to be related to *F. novæ-angliæ* Sulliv., but readily distinguished from this species by the leaves (chiefly the branch leaves) which are narrower, longer acuminate, entire at apex, and by the much smaller and less distinct alar cells. It belongs to the section *Heterophyllæ*.

Habitat: In the Minnesota river channel, at Granite Falls (July 12).

58. **Fabronia octoblepharis** (SCHLEICH.) SCHWÄGR.

On the shaded side of granitic ledges kept moist by trickling water, at Cedar lake (June 18).

At Carlton lake (July 10).

At Granite Falls (July 12).

59. **Fabroleskea austini** (SULL.) BEST. (Determined by Dr. G. N. Best.)

On trees, in Kandiyohi county (June 9–13).

At Foster, on the east shore of Big Stone lake, and southward (June 29).

60. **Leskea arenicola** BEST MS. (Determined by Dr. G. N. Best.)

At base of elm trees, near Montevideo (June 19).

61. **Leskea obscura** HEDW. (Determined by Dr. G. N. Best.)

At base of trees, near Hartford (June 27).

62. **Anomodon attenuatus** (SCHREB.) HÜB. (Determined by Dr. G. N. Best.)

On the shaded side of granitic bowlders and ledges.

At Granite Falls (July 15).

63. **Anomodon minor** (P. BEAUV.) FÜRN. (Determined by Dr. G. N. Best.)

In Kandiyohi county (June 9–13).

Near Montevideo (June 15–21).

At Granite Falls (July 15).

64. **Anomodon rostratus** (HEDW.) SCH. (Determined by Dr. G. N. Best.)

At Cedar lake (June 18).
At Granite Falls (June 13, 14; July 12–15).
At Hartford (June 27).

65. **Cylindrothecium cladorrhizans** (HEDW.) SCH. (Determined by Dr. A. J. Grout.)

At base of trees, near Granite Falls (July 14).

66. **Cylindrothecium seductrix** (HEDW.) SULL. (Determined by Dr. A. J. Grout.)

Growing over stones, at Cedar lake (June 18).
At Granite Falls (July 14).

67. **Platygyrium repens** (BRID.) B. S. (Determined by Dr. A. J. Grout.)

On the ground, in Kandiyohi county (June 9–13).
At Ortonville (June 22).

68. **Climacium dendroides** (L.) WEB. & MOHR. (Determined by Dr. A. J. Grout.)

On a shaded spot, at Granite Falls (July 12).

69. **Thuidium abietinum** (L.) B. S: (Determined by Dr. G. N. Best.)

In broad cushions on rocks, at Montevideo (June 16).
Near Ortonville (June 23).

70. **Thuidium philiberti** LIMPR. (Dr. G. N. Best det.)

On the ground, at Granite Falls (July 14).

71. **Brachythecium acuminatum** (HEDW.) KINDB. (Determined by M. Jules Cardot.)

At the base of trees, near Montevideo (July 6).

72. **Brachythecium acutum** (MITT.) SULL. (Determined by Dr. A. J. Grout.)

On the ground, at Hartford (June 27).

73. **Brachythecium rivulare** B. S. (Determined by Dr. A. J. Grout.)

On wet ground, at Foster (June 29).

74. **Brachythecium rutabulum** (L.) B. S.

On the ground, near Ortonville (June 25).
At Hartford (June 27).

75. **Brachythecium cyrtophyllum** KINDB.

At the base of trees, in Kandiyohi county (June 9–13).
At Montevideo (June 21).
Near Ortonville (June 22).
At Simpson park (June 26).
At Foster (June 29).

76. **Brachythecium oxycladon** (BRID.) JAEG. & SAUERB.

On the ground, in Kandiyohi county (June 9–13).
At Montevideo (June 21).
At Hartford (June 27).
At Foster (June 27).

77. **Eurhynchium strigosum fallax** R. & C. ("Not typical." Grout.)

On the ground, near Montevideo (June 16).

78. **Plagiothecium sullivantiæ** SCH.

On granitic ledges, shaded, and kept moist by trickling water, at Cedar lake, near Montevideo (June 18).

79. **Amblystegium adnatum** (HEDW.) AUST. (Determined by Cardot & Thériot.)

Over rocks and on the ground, at Granite Falls (July 12).

80. **Amblystegium brachyphyllum** Card. & Thér. sp. nov. (Plate XX., 3.)

A. ripario affine, a quo differt foliis brevioribus, ovato-lanceolatis, 1.6–1.7 millim. longis, .7 latis, breviter acuminatis, apice obtuso vel subobtuso. Costa valida, basi dilatata, 50–80 μ lata, usque ad ⅔ vel ¾ folii producta. Cellulæ mediæ lineares, 70–90 μ longæ, 9 μ latæ. Fructus ignotus.

By the blunt or subobtuse acumen this moss resembles *A. vacillans* Sulliv., but it has much shorter and broader leaves. From *A. brevipes* Card. & Thér. it is well distinguished by the larger size, the blunt acumen, the longer and narrower cells, and the stronger costa.

The polymorphous *A. riparium* constitutes a vast group of forms, some of which are constant enough and are sufficiently characterized to be considered as secondary or tertiary species; such are: *A. kochii* Br. eur., *A. vacillans* Sulliv., *A. brachyphyllum* and *A. brevipes* Card. & Thér., *A. floridanum* Ren. & Card., and probably *A. argillicola* Lindb.

Habitat: Granite Falls (July 15).

81. **Amblystegium brevipes** Card. et Thér. sp. nov. (Plate XX., 2.)

E. sectione *A. riparii.* Caulis gracilis, repens, ramis brevibus. Folia erecto-patentia, circa 1.2 millim. longa, .6 lata, late ovata, breviter acuminata, integra, costa angusta, basi 30 μ lata, ultra medium evanida, sæpius ad ⅔ vel ¾ folii producta, rete laxiusculo, cellulis basilaribus rectangulatis, nonnullis quadratis, mediis subhexagonis, 55–70 μ longis, 12–15 μ latis, superioribus brevioribus latioribusque. Folia perichætialia late ovata, in acumine angusto subito constricta, ad basin acuminis sæpe irregulariter denticulata, ultra medium costata. Capsula in pedicello brevi pro more 10, varius 1.5 millim. longo, oblongo-arcuata, sicca sub ore constricta, operculo conico.

This species differs from the small forms of *A. riparium* by the shortly acuminate leaves, the looser areolation, the shape of the perichætial leaves, and the short pedicel. A species from the Caucasus, *A. argillicola* Lindb., of which we know only the description published by Dr. V. F. Brotherus in his valuable paper, *Enumeratio Muscorum Caucasi*, seems to be nearer to this species, but still stands distinct from it by its leaves, which are minutely denticulate from almost the base, its longer costa, vanishing below the apex, and its narrower perichætial bracts with a less distinct nerve.

Habitat: Near Montevideo (June 15); at Hartford (June 27).

82. **Amblystegium compactum** (C. M.) Aust. (Determined by Prof. L. S. Cheney, and by Messieurs Cardot & Thériot.)

M. Cardot remarks on the several forms of this species that he does not separate *A. subcompactum* and *A. dissitifolium* of Kindberg.

Along shady, moist banks of rivulets, at Hartford (June 27). At Foster (June 29).

83. **Amblystegium irriguum** (Wils.) B. S. (Determined by Cardot & Thériot.)

On moist, shaded ground at Hartford (June 27).
At Foster (June 29).

84. **Amblystegium riparium** (Hedw.) B. S. (Determined by Cardot & Thériot.)

On stones near the water's edge, at Cedar Lake (June 18).

85. **Amblystegium riparium trichopodium** Brid. (Determined by F. Renauld, and by Cardot & Thériot.)

On granitic rocks submerged in a stagnant pool of water, near Ortonville (June 25).

86. **Amblystegium serpens** (Hedw.) B. S. (Determined by Prof. L. S. Cheney and by Cardot & Thériot.)

On shaded ground, at Cedar lake (June 18).
Near Ortonville (June 22).
At Hartford (June 27).
At Foster (June 29).

87. **Amblystegium varium** (Hedw.) Lindb. (Determined by Cardot & Thériot.)

In moist situations.
In Kandiyohi county (June 9–13).
At Granite Falls (June 13, 14).
At Simpson Park (June 26).
At Hartford (June 27).
M. Cardot states that the plant from Kandiyohi county is indifferently referable to *A. serpens* or *A. varium*.

88. **Amblystegium varium orthocladon** (Brid.). (Determined by Cardot & Thériot.)

On the ground, at Foster (June 29).

89. **Hypnum aduncum** Hedw. (typicum), forma ad var. *kneiffii* Sch. accedens.

At Foster (June 29).

90. **Hypnum aduncum tenue** Sch. (Determined by Dr. G. N. Best, Prof. L. S. Cheney, and Capt. F. Renauld.)

At Hartford (June 27).
At Foster (June 29).

91. **Hypnum aduncum tenue** Sch., forma **amblystegioides** Ren. in litt.

Near Montevideo (June 19).
Near Ortonville (June 22).
At Hartford (June 27).
Note. — Concerning the Ortonville plant M. Renauld remarks that it "approaches much more closely than the plant from Montevideo to *H. aduncum tenue*." And he suggests that it be designated as forma *amblystegioides*.

The plant from Montevideo is of uncertain relationship. M. Renauld disposes of it by the following suggestions:

"On the one hand the quadrate alar cells form no distinct auricles, suggesting rather an *Amblystegium*. On the other hand the form of the leaves is rather that of *H. aduncum tenue*. The plant being fertile, it ought to be possible to determine the mode of inflorescence. I have not found male flowers, which leads to the suspicion that it is dioicous, and consequently belongs with *Hypnum aduncum;* but inquiry on this point should be made more searching. It is possible that we have to do here with a new species. I commend this plant as well as the one from Ortonville to your attention, since they have in common the *square alar* cells, which form no *auricles*, while the general appearance and the form of the leaves are rather as in *H. aduncum tenue*."

The plant from Hartford is apparently a more luxuriant form of the same species as that from Montevideo. It has the general appearance of *H. filicinum*, agrees fairly in areolation, but lacks paraphyllia. In sending it to M. Renauld I therefore suggested that it looked like a form of *H. filicinum*. Following is his comment: "It is easy to be deceived about the relationship of this plant, which is intermediate between *H. filicinum* and *H. aduncum tenue*. I am on the whole inclined to see in it rather *H. filicinum*. The areolation is very nearly as in this species; the costa is stronger than it is in *H. aduncum*, not reaching the apex, it is true, but I have observed this in several American forms of *Hypnum filicinum*. I have not found any paraphyllia. But there are *radicles*, which are not found on *H. aduncum*. If hybridity in mosses were well demonstrated, I should believe this a hybrid form."

Dr. Best, who has also seen this plant, considers it to be *H. aduncum gracilescens* Sch. And the reference of it rather to some variety of *H. aduncum* than to *H. filicinum* seems, on the whole, to be the more satisfactory disposition. This view appears the more plausible when we consider the richness of forms of *H. aduncum* in the upper Minnesota river valley, together with their numerous intergradations. The explanation lies in the evident susceptibility of *Hypnum aduncum* to variation under extremes of climatic influences which obtain in that region, especially as regards temperature.

92. **Hypnum aduncum intermedium** SCH.

At the edge of water, near Ortonville (June 22, 25).

At Hartford (June 27).

Between Foster and Ortonville (June 29).

At Granite Falls (July 14).

93. **Hypnum aduncum intermedium** SCH., forma **laxa** SCH.

In stagnant water, at Granite Falls (June 14).

94. **Hypnum aduncum intermedium** SCH., forma **laxifolia** SNO., ad group pseudofluitans transiens.

This form was most abundant in a swamp formed in a "prairie kettle," where it covered considerable areas, square rods in extent, excluding apparently all other vegetation, resting like a soft carpet on the water-soaked soil. The whole formation was readily distinguishable at quite a distance by its light yellowish-green color.

In Kandiyohi county (June 9–13).

95. **Hypnum aduncum kneiffii** SCH.

On the edge of the water in the Chippewa river, near Montevideo (June 19).

96. **Hypnum hispidulum** SCH.

At the base of a tree.

In Kandiyohi county (June 9–13).

XIII. TWO NEW SPECIES OF FONTINALIS.

JULES CARDOT.

1. **Fontinalis holzingeri**, sp. nov. (Plate XXI., 2.)

Planta sat mollis, lurido-viridis, subnitens. Caulis basi longe denudatus, flexuosus, 12–20 centim. longus, irregulariter pinnatus, ramis ascendentibus, gracilibus, apice cuspidatis. Folia sat remota, rigidiuscula, erecto-patentia, apice caulis et ramorum convoluto-imbricata, dimorpha: caulina magna, plana, oblongo-vel lineari-lanceolata, sensim angustata, late acuminata, obtusiuscula subacutave integra, 3.5–5 millim. longa, 1–1.5 lata; ramea minora, marginibus inflexis subcanaliculata, apice obtusiusculo acutove, integro vel obsolete denticulato, 2.5–3.5 millim. longa, .6–.8 lata. Cellulæ alares oblongæ vel subquadratæ, parum distinctæ, ceteræ longe lineares, subflexuosæ, sat chlorophyllosæ, parietibus sat firmis, superiores breviores. Flores feminei in caulis parte superiore numerosi; folia perichætialia juniora orbiculari-ovata, apiculata, apiculo obsolete denticulato. Fructus ignotus. Planta mascula femineæ similis; folia perigonialia perichætialibus subsimilia.

Species closely related to *F. missourica*, but distinct by the leaves, which are less soft, of a firmer texture, of longer and thin-walled cells, and the shorter and often subobtuse acumen. The dimorphism of the leaves is little pronounced, and, on this account, *F. holzingeri* rather resembles some species of the group *Malacophyllæ*, but is distinguished from these species by the firmer leaves and the concave subcanaliculate branch leaves.

Habitat: At the second falls of Granite river ascending from Lake Saganaga (June 17, 1897). See MINN. BOT. STUDIES, June 15, 1898, p. 43, where a preliminary description of this species appears.

2. **Fontinalis umbachi** sp. nov. (Plate XXII., 1.)

Planta sicca rigidula, inferne obscure, superne lurido-viridis. Caulis basi denudatus, 7–15 centim. longus, irregulariter pinnatus, ramis remotis patulis vel erecto-patulis, apice cuspidatis. Folia rigidula, erecto-patula, apice caulis et ramorum

convoluto-imbricata, dimorpha: caulina magna, oblongo-lanceolata, sensim late et obtuse acuminata, integra, circa 5 millim. longa, 1.5–1.75 basi lata; ramea multo minora, strictula, ad apicem ramorum curvatula et subhomomalla, anguste lanceolata, marginibus inflexis pro more canaliculata, sensim obtusiuscule acuminata, integra, 3–4 millim. longa, .5–.75 basi lata. Cellulæ alares subquadratæ vel subhexagonæ, parum dilatatæ, ceteræ lineares, subflexuosæ, sat chlorophyllosæ, parietibus crassiusculis sat firmis, superiores breviores. Cetera ignota.

This moss was discovered by Mr. L. M. Umbach, in the Des Plaines river, Illinois, June 18, 1898. But I have recognized in my herbarium some stems of the same plant collected in September, 1895, by Prof. Conway MacMillan in northern Minnesota, near the International Boundary, together with *F. macmillani*, and which I referred erroneously to *F. dichelymoides* Lindb.

Fontinalis umbachi Card. is near *F. missourica* Card., from which, however, it is easily distinguished by its shorter and rather rigid stems, its more shortly acuminate stem leaves and its rigid, canaliculate branch leaves, which are narrower at base and entire at apex. *F. holzingeri* Card. is a softer plant with more elongated and more flexuous stems and smaller stem leaves.

CHARLEVILLE, FRANCE, November 1, 1902.

EXPLANATION OF PLATES.

Nachet's objectives 1, 3, 5 and 6, oculars 1, 2 and 3, with camera lucida.

All drawings are reduced one fourth in photo-engraving. The magnification indicated is true for the *drawings as printed.*

PLATE XIX.

Catharinæa macmillani. 1. Entire plant, slightly enlarged. 2. Stem section. 3. Two perichætial leaves. 4. An antheridium with paraphyses. 5. A leaf apex showing dorsal teeth. 6, 7, 8. Cells from apex, middle and base of leaf. 9, 10, 11, 12. Leaf sections from near apex to near base of leaf. 13, 14. Cells from leaf margin, more enlarged. 15. Cells from lamina, more enlarged.

PLATE XX.

1. *Bryum minnesotense.* *a.* Entire plant, nat. size. *b.* Stem leaf, × 13. *c.* Branch leaf, × 13. *d.* Basal areolation, × 135. *e.*

Areolation in the middle, × 135. *f.* Marginal areolation, × 195. *g.* Capsule in dry state, × 13. *h.* The same in moist state, × 13.

2. *Amblystegium brevipes.* *a.* Entire plant, nat. size. *b*, *b.* Leaves, × 26. *c.* Perichætial leaf, × 26. *d.* Basal areolation of a leaf, × 195. *e.* Areolation in the middle, × 195. *f.* Areolation of the upper part, × 195. *g.* Capsule in dry state, × 13. *h.* The same in a moist state, × 13. *i.* Lid, × 13.

3. *Amblystegium brachyphyllum.* *a.* Entire plant, nat. size. *b.* Leaf, × 26. *c.* Basal areolation of a leaf, × 195. *d.* Areolation in the middle, × 195. *e.* Areolation of the upper part, × 195.

PLATE XXI.

1. *Bryum holzingeri.* *a.* Entire plant, nat. size. *b*, *b.* Stem leaves, × 13. *c.* Branch leaf, × 13. *d.* Basal areolation, × 135. *e.* Areolation in the middle, × 135. *f.* Marginal areolation, × 195. *g.* Capsule in moist state, × 13. *h.* The same in dry state, × 13.

2. *Fontinalis holzingeri.* *a.* Entire plant, nat. size. *b*, *b*, *b.* Stem leaves, × 13. *c*, *c*, *c.* Branch leaves, × 13. *d.* Basal areolation, × 138. *e.* Areolation in the middle, × 138. *f.* Areolation of the apex, × 138. *g.* Young perichætial leaf, with an archegone and two paraphyses, × 32. *h.* Apex of the same, × 138. *i.* Perigonial leaf, × 32. *j.* Another perigonial leaf, with an antheridium, × 32.

PLATE XXII.

1. *Fontinalis umbachi.* *a.* Entire plant, nat. size. *b.* Stem leaf, × 13. *c*, *c*, *c.* Branch leaves, × 13. *d.* Basal areolation, × 138. *e.* Areolation in the middle, × 138. *f.* Areolation of the apex, × 138.

2. *Fontinalis obscura.* *a.* Entire plant, nat. size. *b*, *b*, *b*, *b.* Stem leaves, × 13. *c*, *c*, *c*, *c.* Branch leaves, × 13. *d.* Basal areolation, × 138. *e.* Areolation in the middle, × 138. *f.* Areolation of the apex, × 138.

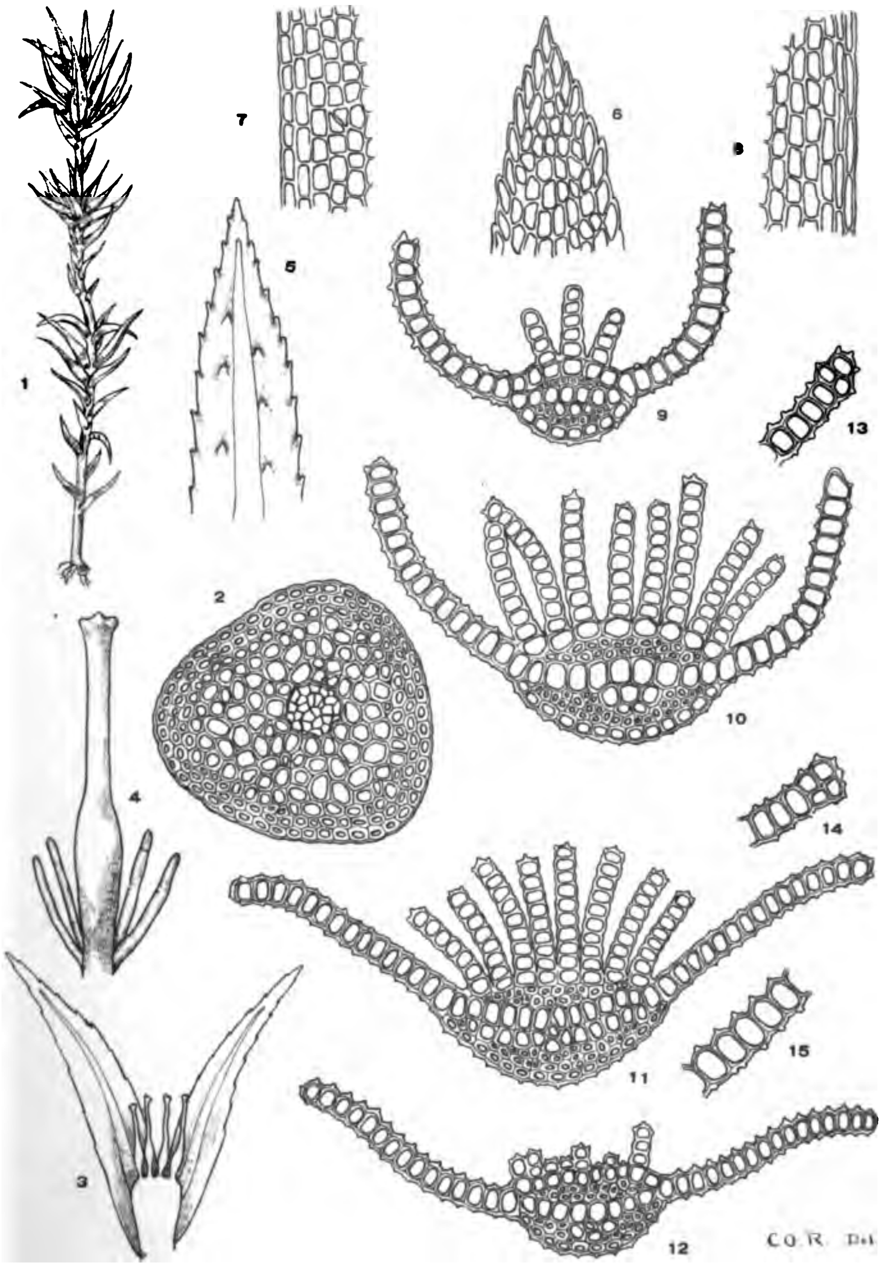
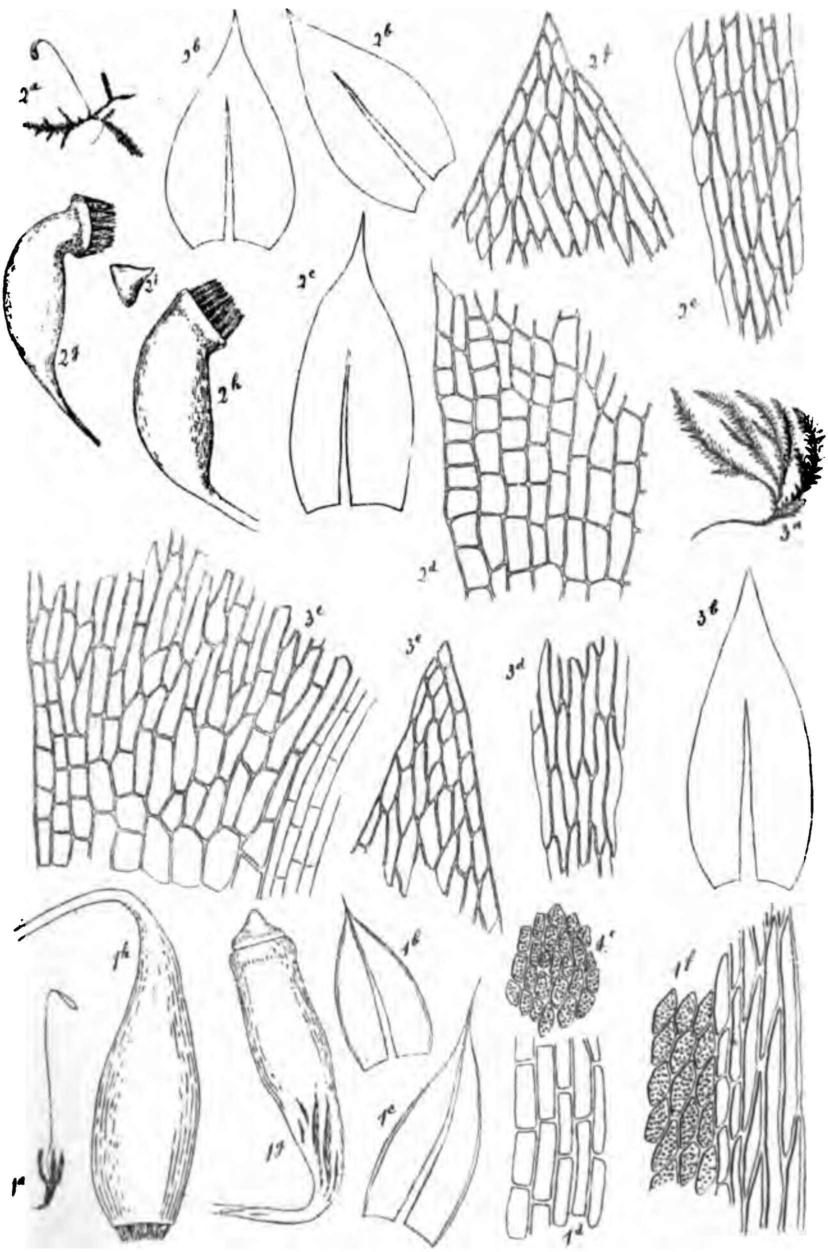


PLATE XIX.

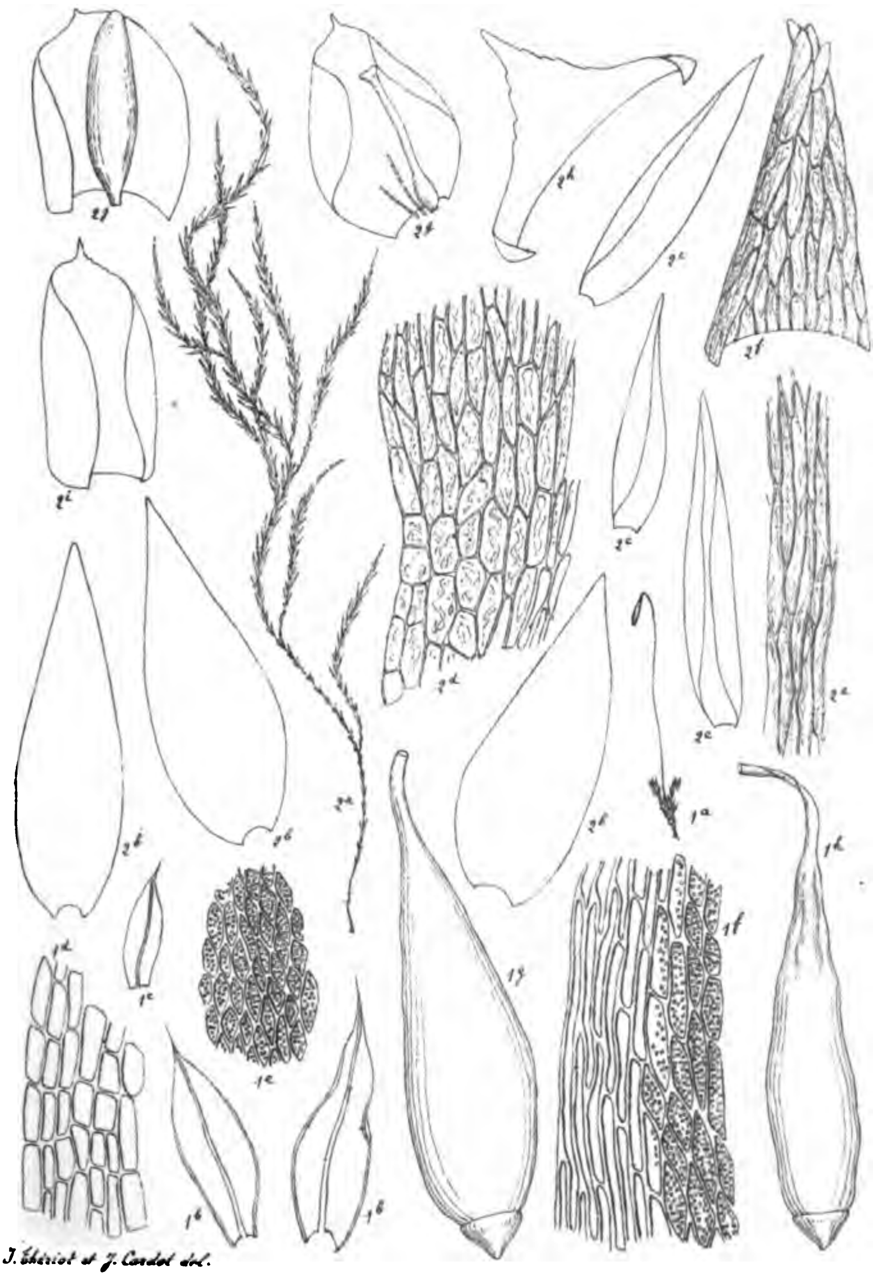
HELIOTYPE CO., BOSTON.



J. Thériot del.

PLATE XX.

HELIOTYPE CO., BOSTON.



J. Thériot et J. Cardot del.

PLATE XXI.

HELIOTYPE CO., BOSTON.

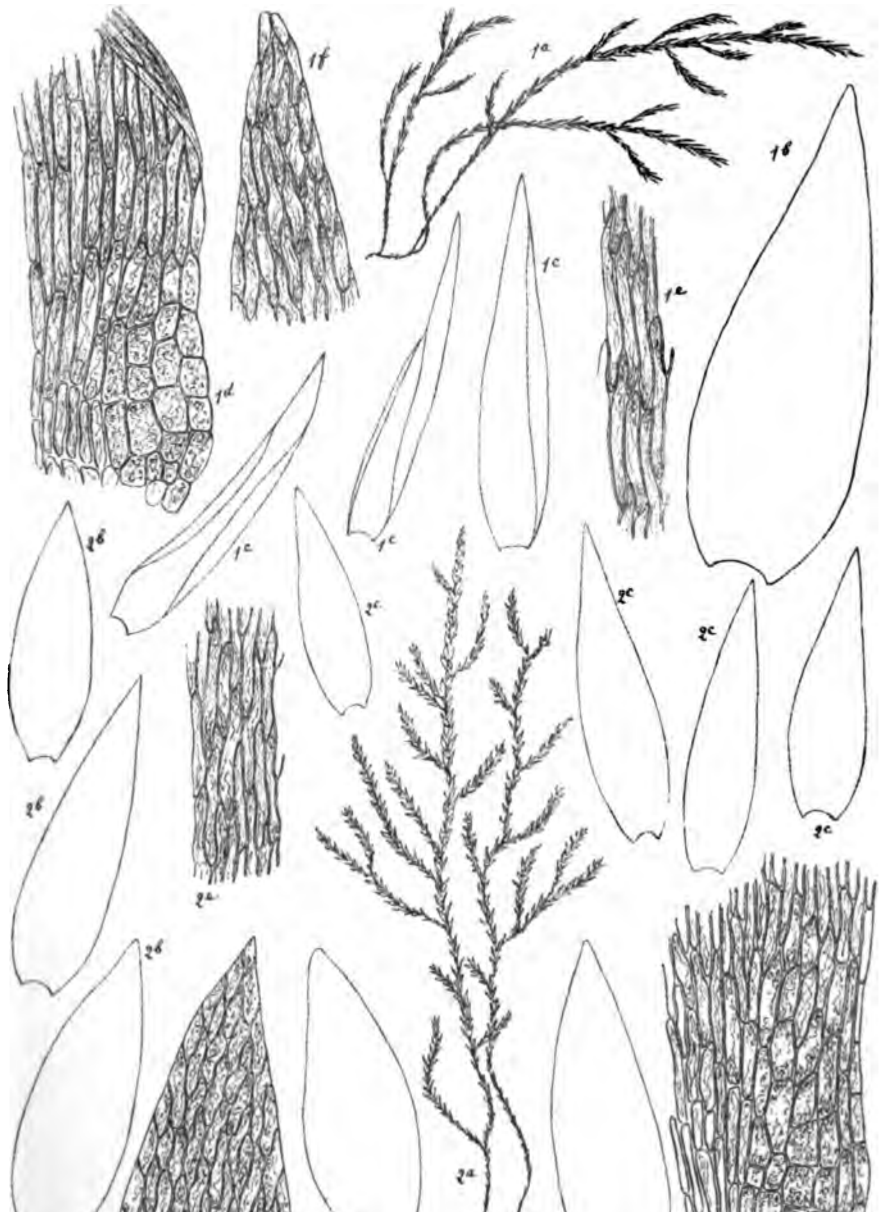


PLATE XXII.

HELIOTYPE CO., BOSTON.

XIV. OUTLINE OF THE HISTORY OF LEGUMINOUS ROOT NODULES AND RHIZOBIA WITH TITLES OF LITERATURE CONCERNING THE FIXATION OF FREE NITROGEN BY PLANTS.—III.

ALBERT SCHNEIDER.

The first and by far the greatest installment of titles was collected by Dr. D. T. MacDougal and appeared in the MINNESOTA BOTANICAL STUDIES, issue of September 27, 1894. The second installment, by the writer, appeared in the same journal, issue of May 31, 1897. In all about 780 titles are given. It is not intended to imply that the list of titles is complete. There are undoubtedly numerous omissions and many of them very important. The writer would be very grateful if those interested would supply from time to time titles not already given.

At some future time it is intended to prepare a fairly complete history of the study of leguminous root nodules, and rhizobia, accompanied by a citation up to date of the more important titles on the subject, giving the titles in alphabetical as well as in chronological order. Such a record is intended for the benefit of future investigators. The following preliminary outline is intended to indicate the plan which is to be followed and suggestions and criticisms would be highly appreciated.

FIRST PERIOD: INITIAL STUDY OF LEGUMINOUS ROOT TUBERCLES—FROM CLOS (1848) TO LAWES AND GILBERT (1860).

During this period nothing of marked scientific value was done regarding the root tubercles of leguminous plants. Occasional attention was called to their presence and theoretical or hypothetical assumptions were made regarding their function and structural nature. Clos was among the first to make more extended observations and call especial attention to them, expressing it as his opinion that they were lenticular outgrowths of the roots. Malpighi was perhaps the first author of note to

mention them. In his Anatomy of Plants (1687) he describes them as galls, without stating definitely what caused their development. De Candolle (1825) looked upon them as pathological outgrowths, likewise refraining from expressing a definite opinion as regards their origin. Treviranus expressed the opinion that they were undeveloped buds.

SECOND PERIOD: COLLATERAL INVESTIGATIONS WHICH LED TO THE DISCOVERY OF THE TRUE NATURE OF ROOT TUBERCLES — FROM LAWES AND GILBERT (1860) TO FRANK (1879).

Perhaps criticism may be made for giving this as a period in the history of the subject under discussion since the investigations referred to originally had absolutely no relationship to the study of leguminous root nodules, nor did the investigators about to be mentioned have any conception of the significance of these root structures when they planned and began their researches.

The chief investigators of this period were Lawes and Gilbert of England and Hellriegel and Willfarth of Germany. Their investigations pertained to the differences in the nitrogen supply and nitrogen assimilation of certain plants, as grasses, sugar beets, and leguminous plants. The final conclusion reached by Hellriegel was that there was some definite significant relationship between the root nodules and nitrogen assimilation of leguminous plants. Immediately these root tubercles were given marked attention which led to the discovery of their characteristic contents, namely the bacteria, now more generally known by the generic name rhizobia.

THIRD PERIOD: THE SCIENTIFIC INVESTIGATION OF LEGUMINOUS ROOT TUBERCLES AND RHIZOBIA — FROM FRANK (1879) TO SCHNEIDER (1893).

The first work of this period was really not done by Frank (see Woronin and Hellriegel) but this investigator certainly took the lead in doing active painstaking work in the study of the leguminous root tubercles as well as the contained rhizobia. Numerous other investigators of Germany, France, England and America also did excellent work. Disputes and changes of opinion were frequent. Not until the close of the period were satisfactory conclusions reached regarding the true nature of the root tubercles and the biological identity of the rhizobia.

Fourth Period: Preliminary Investigations Relating to the Possible and Probable Practical Utility of Rhizobia and Functionally Related Organisms. From Schneider (1893) to ——.

This period corresponds to a period of renewed activity on the part of investigators. As far as known the first paper outlining a course of research and giving a preliminary report of work done with regard to the possible practical utility of rhizobia in agriculture appeared in 1893, followed in 1896 by the preliminary reports of researches by Nobbe and Hiltner and still later reports by Hartleb and Caran. So far no entirely satisfactory results have been obtained, but it is hoped that in the near future (five to ten years or more) satisfactory and conclusive results may be obtained which will initiate the fifth period, namely the Economic Value of Rhizobia and Functionally Related Organisms.

For the benefit of those interested, it may be stated that nearly all of the titles of literature of the fourth period (up to date) are found in the following list. A few are found in the first and second installments.

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CHICAGO.

XV. REPORT ON TWO COLLECTIONS OF HEPATICÆ FROM NORTHEASTERN MINNESOTA.

ALEXANDER W. EVANS.

The two collections embodied in the present report were both made in Cook county, the first by Messrs. MacMillan, Lyon and Brand, in 1901, the second by Mr. Holzinger in 1902. Although these collections contain no new species, they add quite a little to our knowledge of the distribution of Hepaticæ in North America. Thirty-two species, all belonging to the Jungermanniaceæ, are represented, and the collection of 1901 contains in addition a sterile *Pellia* and a sterile *Riccardia*, neither of which can be determined with certainty. So far as can be learned, sixteen of the thirty-two species are here recorded from Minnesota for the first time, and three of these, *Lophozia rutheana*, *Sphenolobus exsectæformis* and *Odontoschisma macounii*, have not before been reported south of the Canadian boundary. The numbers refer to the specimens in the collection of 1901; Mr. Holzinger's specimens, which are unnumbered, are simply designated by his initial; species new to Minnesota are marked with an asterisk.

1. **Marsupella emarginata** (EHRH.) DUMORT.*
Near Grand Marais (H).

2. **Jamesoniella autumnalis** (DC.) STEPH.
Grand Marais (24); portage between North and South lakes (143 *p. p.*); Arrow lake (172 *p. p.*); Stair portage (164); Grand Portage island, Old Iron trail, Little Devil's Track trail and Gunflint trail (H).

3. **Lophozia barbata** (SCHREB.) DUMORT.
Grand Marais and vicinity (183 *p. p.*, 238, H); Stair portage (181 *p. p.*); summit of Mt. Josephine (H).

4. **Lophozia heterocolpa** (THED.) M. A. HOWE.*
Near Grand Marais (H).

5. **Lophozia incisa** (SCHRAD.) DUMORT.

Gunflint trail (48 *p. p.*); Grand Portage island and Hat point (H).

6. **Lophozia Lyoni** (TAYL.) STEPH.

Portage between North and South lakes (143 *p. p.*); Stair portage (181 *p. p.*); summit of Mt. Josephine and Hat point (H).

7. **Lophozia Rutheana** (LIMPR.) M. A. HOWE.*

Near Grand Marais (H). Previously known in America from the Yukon Territory only.

8. **Lophozia ventricosa** (DICKS.) DUMORT.

Grand Marais and vicinity (231 *p.p.*, H); portage between North and South lakes (143 *p.p.*); Gunflint trail and Hat point (H).

9. **Sphenolobus exsectæformis** (BREIDL.) STEPH.*

Near Grand Marais (H). This species is very closely related to the following but differs from it in its larger leaf-cells and angular gemmæ. It was first recognized as an American plant by M. Dismier,[1] who examined specimens collected by Professor Macoun in British Columbia. It is now known from many localities in Europe and probably has an equally wide distribution in North America.

10. **Sphenolobus exsectus** (SCHMID.) STEPH.*

Near Grand Marais (H).

11. **Sphenolobus Hellerianus** (NEES) STEPH.*

Portage between North and South lakes (143 *p.p.*); Little Devil's Track trail (H). Badly mixed in both cases with other hepatics.

12. **Sphenolobus Michauxii** (WEB.) STEPH.*

Stair portage (182).

13. **Plagiochila asplenioides** (L.) DUMORT.

Near Grand Marais (H).

14. **Lophocolea heterophylla** (SCHRAD.) DUMORT.

Grand Marais (22, 28); Grand Portage island and Little Devil's Track trail (H).

15. **Harpanthus Flotowianus** NEES.*

Near Grand Marais (H).

[1] Bull. Soc. Bot. de France, 49 : 209. 1902.

16. **Cephalozia bicuspidata** (L.) DUMORT.*
Near Grand Marais (H).

17. **Cephalozia catenulata** (HÜBEN.).
Grand Marais (236).

18. **Cephalozia curvifolia** (DICKS.) DUMORT.
Portage between North and South lakes (140); Arrow lake (172 *p.p.*); Stair portage (165, 187); Hungry Jack lake (88); Old Iron trail, Little Devil's Track trail and Gunflint trail (H).

19. **Cephalozia divaricata** (SM.) DUMORT.*
Near Grand Marais and at summit of Mt. Josephine (H).

20. **Cephalozia fluitans** (NEES) SPRUCE.*
Grand Marais (231 *p.p.*).

21. **Odontoschisma Macounii** (AUST.) UNDERW.*
Near Grand Marais (H).

22. **Bazzania trilobata** (L.) S. F. GRAY.
Grand Marais (211); Gunflint trail (21, H); Old Iron trail, Hat point and base of Mt. Josephine (H).

23. **Lepidozia reptans** (L.) DUMORT.
Grand Marais (183 *p.p.*); portage between North and South lakes (143 *p.p.*); Stair portage (166); Grand Portage island, Little Devil's Track trail, Gunflint trail and Hat point (H).

24. **Blepharostoma trichophyllum** (L.) DUMORT.
Portage between North and South lakes (143 *p.p.*); Gunflint trail (48 *p.p.*, 58, H); Grand Marais, Old Iron trail and Little Devil's Track trail (H).

25. **Ptilidium ciliare** (L.) NEES.
Grand Marais and vicinity (25, 26, 27, H); portage between North and South lakes (142); Stair portage (184); Gunflint trail (51, 53, H); Reve Lake portage (175); Grand Portage island, Old Iron trail, summit of Mt. Josephine and Hat point (H).

26. **Scapania subalpina** (NEES) DUMORT.*
Near Grand Marais (H).

27. **Scapania undulata** (L.) DUMORT.*
Clear Creek, at crossing of Gunflint trail (46); near Grand Marais and Gunflint trail (H).

28. **Radula complanata** (L.) DUMORT.

Gunflint trail (56, H); Grand Portage island and Old Iron trail (H).

29. **Porella platyphylla** (L.) LINDB.

Old Iron trail (H).

30. **Porella rivularis** (NEES) TREVIS.*

Stair portage (42).

31. **Frullania Eboracensis** GOTTSCHE.

Grand Marais and vicinity (30, 245, H); portage between North and South Lakes (139, 141, 144); Stair portage (191); Poplar creek (113); Gunflint lake (38 *p.p.*); Grand Portage sland, Old Iron trail and Little Devil's Track trail (H).

32. **Frullania Oakesiana** AUST.*

Gunflint lake (38 *p.p.*); Little Devil's Track trail (H). The discovery of this species in Minnesota makes a very interesting extension of its known range. It had previously been reported from New England and Nova Scotia only and was supposed to have a rather restricted geographical distribution.

YALE UNIVERSITY.

XVI. OBSERVATIONS ON THE TIDE POOL VEGETATION OF PORT RENFREW.

S. A. SKINNER.

During the summer of 1902 I had the privilege of spending a part of the months of July and August at the Minnesota Seaside Station at Port Renfrew, Vancouver Island, B. C.

The observations upon which this article is based were made during that time, at the suggestion of Professor Conway MacMillan, and I am greatly indebted both to Professor MacMillan and to Miss Josephine E. Tilden for many valuable suggestions and for assistance in determining the plants collected.

The problem studied is of interest not only in the determination of the plants of the various tide pools, but it becomes of some ecological importance as well when the various factors which have an influence on the distribution of the vegetation of the different pools are taken into consideration.

The following conditions received especial attention in the series of pools studied.

The rock formation in which the pool occurs.

Its location, whether high-tide, mid-tide, or low-tide.

Its distance from the ocean and its elevation.

Its exposure to wave action; its position relative to direction of movement of the wave; the direction of drainage.

The nature of the pool; dimensions; condition of the bottom; condition and position of the sides.

A series of eight pools was studied with some degree of care. The water was removed either with buckets or by syphons improvised from *Nereocystis* stems, and observations both at high and low tide were made.

The pools studied were situated on a ridge of rocks which jutted into the sea some sixty feet and was about thirty feet across at its widest point. It was exposed to wave action on the south, west and east.

The ridge descends gradually to the south by a series of nearly horizontal planes, each plane being from two to four feet

lower than the one above, The lower plane slopes gradually to the surface of the water at medium low tide, ending in an abrupt ledge about six feet high, which is exposed only at times of very low tide.

One or more pools from each plane were selected and studied. The formation in which this series occurs may be best described as a somewhat hard coarse sandstone, weathering in rather irregular masses, plentifully sprinkled with bowlders or concretions of a somewhat harder character. These concretions seem to be largely responsible for the origin of many of the pools of this locality. Becoming loosened in their beds, in the cavity thus formed, they are used by the waves as chisels, cutting out in the course of time pools several feet in depth and diameter. In many of the pools these "chisels" are still actively at work.

Pool No. I.

Location.—High tide pool. Situated on the summit of the ridge about fifteen feet above the water at medium low tide: Distant from the edge of the ridge twenty-five feet.

Exposure to Tide.—On August 9th, during high tide, the pool was entered but twice and then only by small dashes of spray thrown up from below.

On August 11th, during a squall at high tide it was filled repeatedly in the same manner. The water entered from the southwest. Drainage was to south and west.

Shape and Dimensions.—Nearly circular. Greatest diameter four and one half feet. Depth two and one half feet.

Bottom quite smooth except for the presence of a few small pebbles. Sides smooth. North side sloping. South side almost perpendicular except for a shelf of rock which extends along the south and part of the east and west sides.

Flora: Kind and Distribution.

1. **Corallina aculeata.**

On the shelf on the south and on the sloping side on the north extending across the bottom of the pool. All except a few plants at the bottom appeared to be dead.

2. **Codium mucronatum.**

About twelve specimens were found on the west and south side near the bottom. All of the upper ones were seemingly dead.

3. **Enteromorpha** sp.

Near the rim of the pool a few, seemingly dead, specimens were found.

POOL No. II.

Location.—High tide pool. At a level about four feet below Pool No. I.

Exposure to Tide.—Filled mostly by surf thrown up from west and southwest. Drainage in same direction. During a squall at high tide some waves rolled completely across the pool.

Shape and Dimensions.—Elongated northeast and southwest. Diameter four and one half feet. Depth two and one half feet.

Bottom is covered with small pebbles and several larger rocks from one to two and one half feet long. Sides uneven. South wall overhanging. On east, west, and north there is a gentle slope for a short distance, then an abrupt descent to the bottom.

Flora: Kind and Distribution.

1. **Cladophora** sp.

Occurs abundantly around the pool.

2. **Corallina aculeata.**

Occupies a zone about four inches wide around the rim of the pool. Upper plants seemingly dead.

3. **Phyllospadix scouleri.**

Occupies a zone about eight inches wide below No. 1.

Following down some cracks nearly to the bottom, and again lowering itself by means of long stout runners over an almost smooth perpendicular surface to some point below where a foothold can be obtained.

4. **Codium mucronatum.**

Eight plants were found under the overhanging wall on the southeast.

5. **Amphiroa cretacea.**

Two plants were found in a crevice below the *Phyllospadix* and sheltered by it.

6. **Cheilosporum planiusculum.**

Occupies a zone below the *Phyllospadix.*

The lower twelve inches of the pool were free from plant life.

Pool No. III.

Location.—Mid-tide pool. At a level one half foot below. No. 2. Distance from the ridge twenty feet.

Exposure to Tide.—During high tide filled repeatedly from south and west and subject also to a strong return flow as the waves are thrown back from the edge of the ledge above. Drainage to the south and west.

Shape and Dimensions.—Nearly circular. Greatest diameter three feet. Depth two and one half feet.

Sides smooth and uniform, almost perpendicular with the edge overhanging at the very top. Bottom covered by stones varying in size from a small marble to rocks two feet in length.

Flora: Kind and Distribution.

1. **Corallina aculeata.**

Occupies a zone around the rim of pool for three inches.

2. **Amphiroa cretacea.**

Occurs below No. 1, creeping down cracks nearly to the bottom of the pool.

3. **Amphiroa tuberculosa.**

Associated with No. 2.

4. **Codium mucronatum.**

Occupies a zone around the pool about eight inches from the top. Most abundant on the south side from which the waves enter.

5. **Codium adhærens.**

Occurs on south side with No. 4.

6. **Polysiphonia** sp.

Abundant with No. 4.

7. **Gigartina** sp.

Occurs around the edge of pool in small tufts.

8. **Cladophora.**

A few specimens occur a few inches below the rim of the pool.

9. **Cheilosporum californicum.**

Occurs on south side below No. 1.

10. **Corallina vancouveriensis.**

Associated with No. 1.

11. **Cheilosporum planiusculum.**

Occurs near the bottom of the pool on the north.

Pool No. IV.

Location. — Mid-tide pool. At a level three feet below No. 3. Distant from the edge of the ridge twelve feet.

Exposure to Tide. — The pool is filled repeatedly at mid tide. An occasional wave enters from the southwest but in general the pool is filled from the east end by the surf thrown up as a wave is broken violently on the ledge to the east.

The drainage is to the south and southwest. The west end of the pool is left usually in comparative quiet.

Shape and Dimensions. — Diameter east and west eleven feet. Diameter north and south six and one half feet. Depth six and one half feet.

In general the edge of the pool overhangs slightly. Sides quite smooth and regular, occasionally broken with crevices and holes. Below the overhanging rim the sides on the north and south slope gradually to the bottom. The east side recedes uniformly. On the west, about one foot below the surface, a shelf of rocks projects. Below this shelf the side slopes gradually to the bottom.

Bottom quite regular. Covered with rocks of various size.

Flora: Kind and Distribution.

1. **Corallina vancouveriensis.**

Occurs around the rim of the pool on the north and west, extends down four feet.

2. **Rhodomela larix** sp. with *Soranthera ulvoides.*

Occupies a zone about one foot wide three feet below the surface.

3. **Phyllospadix scouleri.**

Occurs on the northwest, west, and southwest. On the northwest it extends nearly to the bottom.

4. **Cheilosporum californicum.**

Occurs three feet below the surface on the east and south beneath No. 2.

5. **Cheilosporum frondescens.**

Occurs about four feet below the surface on the south and north. Seemingly protected by Nos. 5 and 3.

6. **Amphiroa cretacea.**

Occurs below the *Phyllospadix* on the northwest and southwest, three feet below the surface.

7. **Laminaria cloustoni.**

One plant was found in a crevice on the south and one on the east three feet below the surface.

8. **Codium mucronatum.**

A few plants occur on the north one and one half feet below the surface.

9. **Costaria turneri.**

One plant was found one foot below the surface on the west and one three feet below the surface on the east.

10. **Laminaria bullata.**

One plant was found on the east end three feet below the surface.

11. **Codium adhærens.**

A small amount occurs on the southwest end, one foot below the surface.

Pool No. V.

Location.—Mid-tide pool. On a level three feet below No. 4. Distant from the edge of the ridge one foot.

Exposure to the Tide.—The waves enter from the east and southwest. The waves thus coming from nearly opposite directions frequently meet and give rise to a strong vortex motion.

Shape and Dimensions.—Circular. Edge overhanging on the north and east. The sides slope gradually for about two and one half feet and then recede. On the south and west the sides recede from the very top. Sides, in general smooth but pitted somewhat with small holes.

Bottom covered with small pebbles which are kept in almost constant movement by the vortex action mentioned above.

Diameter four and one half feet. Depth four and one half feet.

Flora: Kind and Distribution.

1. **Corallina aculeata.**

Occurs on the northeast side for about two and one half feet.

2. **Cheilosporum planiusculum.**

A few plants occur with No. 1.

3. **Callophyllis** sp.

Occurs on the northeast with No. 1.

4. **Iridæa** sp.

A few plants occur along the upper edge on the east.

5. **Corallina vancouveriensis.**

A few plants occur below No. 1.

6. **Microcladia borealis.**

A few plants were associated with No. 3.

7. **Endocladia muricata.**

Occurs under a small ledge on the southwest near the surface.

8. **Codium adhærens.**

A few plants occur under an overhanging ledge on the north near the top.

The lower two and one half feet of the pool has no plant life.

Pool No. VI.

Location. — Mid-tide pool. On a level four feet below No. 3. Distant from the edge of the ridge four feet.

Exposure to Tide.—The water enters from the south and west and drains to the south, west and east.

Shape and Dimensions.—Irregular in shape. It consists of a deep nearly circular part on the east, and a shallow arm extending to the west. The south and west walls of the shallow arm are abrupt. The north side slopes gradually. The bottom is thickly covered with mussels.

The sides of the circular part of the pool are almost perpendicular. Very irregular. Covered with holes and cracks. The edge somewhat overhanging. The bottom is covered with pebbles and rocks.

Diameter of circular pool four feet. Depth three and one half feet.

Shallow arm. Length six feet. Width three feet. Depth three feet.

Flora: Kind and Distribution.

No plants occur on the south side of the circular pool except at the very edge. On the other sides they extend down two feet. The bottom of the shallow arm is abundantly covered with plant life.

1. **Phyllospadix scouleri.**

Occurs abundantly around the upper edge of the circular pool on the southwest and west, and a few much worn plants on the north. In the shallow arm it occurs on the south side and across the bottom.

2. **Cheilosporum frondescens.**

Occurs around the upper edge of the pool on the north and northeast. Extending down one foot. It occurs abundantly on the bottom of the shallow arm.

3. **Cheilosporum planiusculum.**

Occupies a zone below No. 1, following down crack two feet below the furface.

Abundant on bottom of shallow arm.

4. **Cheilosporum californicum.**

Occurs below No. 2 in protected crevices and beneath the *Phyllospadix.*

5. **Polysiphonia** sp.

Occurs in scattered tufts over the bottom of the shallow arm.

6. **Corallina aculeata.**

A small amount occurs beneath No. 1 on the south side of the shallow arm.

7. **Amphiroa cretacea.**

A few plants were found on a mussel on south side of the shallow arm.

POOL No. VII.

Location.—Mid-tide pool. At a level one half foot below No. 6. Distance from edge of ridge four feet.

Exposure to Tide.—The waves enter from southwest and drain to the southwest and east. The pool is subject to a vortex action as described in No. 5.

Shape and Dimensions.—Circular. Sides covered with mussels. South side somewhat overhanging. The other sides almost perpendicular.

Bottom covered with small pebbles. Diameter three feet. Depth two feet.

Flora: Kind and Distribution.

1. **Corallina vancouveriensis.**

Occurs around the edge of the pool except on the south. Extending down eight inches.

2. **Cheilosporum planiusculum.**

Associated with No. 1.

3. **Amphiroa cretacea.**

Covering a group of mussels on the southeast below No. 1.

4. **Halosaccion hydrophora.**

A very imperfect specimen was found under the overhanging ledge on the south.

Pool No. VIII.

Location. — Low-tide pool. About ten feet from the end of the ridge.

Exposure to Tide. — The waves enter from the southwest and drain to the southwest. Subject to a strong back flow. The pool is free from the surf but a few minutes at a time during low tide. During high tide the pool receives both surf and surge.

Shape and Dimensions. — Irregular in shape. Consisting of a rather shallow part on the north and a smaller deeper part on the south. Sides and bottom covered with mussels except the small pool on the south which has its bottom covered with pebbles.

Dimensions eight feet by six feet. Depth of small pool two and one half feet.

Flora: Kind and Distribution.

1. **Corallina aculeata.**

Occurs around the edge of the pool and sparingly over the bottom.

2. **Cheilosporum californicum.**

Occurs over the bottom on the mussels.

3. **Laminaria clustoni.**

Several small plants on the north in exposed position.

4. **Hedophyllum subsessile.**

Abundant over the pool.

5. **Alaria** sp.

A few plants occur on the bottom in an exposed position.

6. **Iridæa** sp.

A few plants found with No. 3.

7. **Lessoniopsis littoralis.**

Several plants occur on the edge of the deeper pool. Greatly exposed to the surf.

8. **Polysiphonia** sp.

Abundant over the bottom.

9. **Cheilosporum planiusculum.**

Covering the mussels on the bottom of the pool.

10. **Corallina vancouveriensis.**

Associated with No. 9.

SUMMARY.

A comparison of the preceding results admits of the following generalizations.

I. *Corallina aculeata* inhabits the high-tide pools and occupies a zone near the surface of the mid-tide and low-tide pools. *Corallina vancouveriensis* was not found so abundantly in the series studied but occupies a zone similar to *Corallina aculeata*.

The species of *Cheilosporum* occur abundantly in the mid-tide and low tide pools.

Cheilosporum planiusculum seems to have somewhat the wider range, extending from the surface to a depth of two and one half feet to three feet. *Cheilosporum frondescens* and *Cheilosporum californicum* occur in general from one to four feet below the surface, frequently covering the mussels on the bottom of the pool.

Amphiroa cretacea and *Amphiroa tuberculosa* occur in the mid-tide and low-tide pools at some distance from the surface, frequently covering the mussels on the bottom and sides of the pool.

Phyllospadix occurs in general around the surface of the pool, in some cases extending some distance toward the bottom as convenient footholds offer and occasionally swinging by means of long stout rhizomes over a smooth perpendicular wall to some coveted point below. It seems to choose the more sheltered places where it will be free from the shock of the waves. If in an exposed position the plants found were always much frayed and battered.

The various surge and surf plants such as *Lessoniopsis*, *Laminaria*, *Hedophyllum* and *Costaria* occur in somewhat limited numbers in the low tide pools. *Lessoniopsis*, true to its nature, choosing the place of greatest exposure.

The species of *Codium* were found in the more sheltered parts of the pools, usually where the illumination was weak.

II. In general the higher the elevation of the pool and the less exposed to wave action, the fewer the species found, though the number of individuals may be abundant.

III. The more gradual the slope and the rougher and more irregular the sides, the more abundant the plant life. A perpendicular or receding wall is unfavorable for the location of plants.

IV. The presence of pebbles and loose rocks on the bottom of a pool prevent the distribution of plants over the bottom or far down the sides of the pool.

V. Pools which are subject to a strong vortex action are more or less completely circular in outline.

Where the waves enter quite uniformly from the same direction the pool is usually elongated in the direction of movement of the wave.

The work on tide pools, as outlined above, must be considered in no sense complete. Several conditions which have an influence on tide pool vegetation have received no consideration in this article. The effect of temperature; the effect of illumination; the condition of the water in regard to its salinity; the rate of repopulation of a pool from which all plant life has been removed and a comparison of the tide pools of the different rock formations occurring at Port Renfrew readily suggest conditions, the investigation of which should prove both interesting and profitable.

XVII. OBSERVATIONS ON ALARIA NANA SP. NOV.

HERMAN F. SCHRADER.

INTRODUCTION.

The genus *Alaria* is represented at the Minnesota Seaside Station by at least two species. The larger of these, *Alaria cordata* Tilden, is chiefly found in the same zone as *Egregia* and various species of *Laminaria*, attached to rocks which are seldom exposed except at low tide. It often reaches a length of six feet or more.

The species on which these observations are based, is found only among the *Postelsiæ*, attached to rocks which are seldom submerged completely, except at high tide, but which are always exposed to surf.

Part of the general morphology was studied from fresh material, but most of these observations are based on preserved material, collected by the writer, at the Minnesota Seaside Station during July and August, 1902.

Distribution.—The genus *Alaria* was founded by Greville in 1830. At present, according to Kjellman, eighteen or nineteen species are recognized, most of which are North Pacific and Arctic. Three species are North Atlantic, one of them extending as far south as the coast of Ireland and of France (De Toni, *Alaria esculenta*).

GENERAL MORPHOLOGY.

The young plants are usually found growing among the branches of the holdfast of maturer forms of their own species, or of *Postelsia palmæformis*, along with other young kelps, coralline algæ and acorn barnacles. The writer succeeded in collecting young specimens, less than two centimeters long, others, a little more mature, showing the first appearance of the gonidiophylls, and also mature specimens in all conditions. The species under discussion is small, for two of the most typi-

cal specimens were but thirty-two and forty-two centimeters long, respectively, and the largest specimen seen was not more than a third longer than this.

In all these specimens, a root or holdfast area, and a shoot, or stipe and lamina area, could be made out. The broad characteristic midrib was present in all, and even in the smallest specimens collected, it was just as wide and thick, comparatively speaking, as in the largest plants. The presence of this midrib makes it easy for a collector to determine whether he is handling an *Alaria* or another kelp.

The following figures give the measurements in centimeters of four typical young plants, and of two of the largest specimens collected.

Plant number,	1.	2.	3.	4.	5.	6.
Total length,	3.	1.5	4.	5.5	42.	32.
Length of stipe area including rachis,	.75	.4	.75	1.5	10.	6.
Width of lamina,	1.	.6	1.75	3.2	8.	6.5
Width of midrib,	.3	.1	.3	.5	.75	.6
Length of gonidiophyll,				*	10.2	8.
Width of gonidiophyll,					2.55	2.25
Number of gonidiophylls,					44.	32.

Alaria is unbranched and the chief difference between a young and a mature plant is the absence of gonidiophylls in the former. The largest specimen collected was but forty-two centimeters long, rather small, when one considers that specimens of other species, six feet or more in length, may be found less than a hundred yards away. In healthy specimens the tissue of the lamina is elastic and thin, but when the plant gets older, portions of the lamina begin to decay, forming large bladders of mucilage all over the surface. Perfect mature specimens are seldom if ever found, owing to the violent beating of the surf on the rocks to which they are attached.

The holdfast area is well developed in this *Alaria*. In the youngest plants collected, it consists merely of a small disc-shaped area, very little wider than the diameter of the stipe. Above this disc-shaped portion a few hapteric branches grow out from the base of the stipe. In larger specimens there are a great number of these hapteres. They are brown in color, branch dichotomously, and their tips are flattened somewhat where they clasp the rocks. These hapteres form a dense and solid network, between the meshes of which the young plants find a secure foothold.

* Two gonidiophylls appearing on upper portion of stipe.

The stipe is rather dark in color, especially in older plants. Its general shape is terete, but the upper or rachis portion, upon which the gonidiophylls are borne, becomes somewhat elliptical in shape as it reaches the lamina, where it becomes the midrib. The surface of the stipe is smooth; it is tough, and does not branch although it gives rise to the gonidiophylls in the area just below the lamina.

The lamina is lighter in color than the stipe. It is rather thin and elastic, and varies in maximum width from about one eighth to one sixth of its length. A thick midrib runs through the center, and the lamina proper may be considered as simply a flattened expansion of the midrib. In perfect specimens the lamina tapers somewhat at the tip, but owing to the action of the surf, the lamina is usually torn considerably at its upper end, sometimes only the midrib remaining to show the former length.

The gonidiophylls are proliferations of the stipe, situated just below the base of the lamina. When they first appear they look like little, conical, smooth outgrowths, on the side of the stipe. As they elongate, they flatten out. They vary considerably in number, according to the size and age of the plant on which they are borne, and from thirty to forty or more in mature specimens is nothing unusual. The oldest gonidiophylls are found nearest the base of the cluster, the youngest nearest the lamina. They have no midrib, nor any similar structure, but their base is somewhat thickened and narrowed into a short stalk, which does not differ in structure from the rest of the gonidiophyll except that it is sterile. The color is almost as dark as that of the stipe. Patches of sori, consisting of gonidangia and paraphyses are found on both sides, except in the case of the very young gonidiophylls.

Anatomy.

The anatomical study was based upon slides, made from both young and old material. Most of the material was killed in formalin solution four per cent. and before being used was washed for twenty-four hours in running water, dehydrated and embedded in paraffin by the usual methods. Most of the sections were stained on the slide, and mounted in Canada balsam, but in some cases it was found that heating the sections in order to fasten them to the slide distorted them. In such cases the sections were dissolved out in xylol, gradually brought into

fifty per cent. alcohol, and after staining, mounted in glycerine jelly. Free-hand sections were found best for the cross-section of the stipe. Bismarck brown, iron-alum-hæmatoxylin, and Delafield's hæmatoxylin, were on the whole the most satisfactory stains, although aniline blue and safranin were found useful for sections of the stipe.

The Holdfast.—The holdfast area consists originally of a disc-like structure, as in *Nereocystis* and other kelps. In the smallest specimen at the writer's disposal the first few hapteric branches had already appeared but the primitive disc could still be made out without much difficulty. The hapteres originate in a special growth region at the base of the stipe (*fig. 18*, *fig. 11*, *b*, *fig. 20*) just above the primitive disc. They branch dichotomously. In cross-section (*fig. 11*, *b*) it is seen that no pith area is present in the hapteres, but that their central tissue is parenchymatous, consisting of rather large cells of irregular shape, which gradually become smaller as the hypodermis and epidermis are reached. Chloroplasts are very common in the hypodermal tissue of hapteres, especially the upper portion. By comparing the longitudinal and cross-sections of the haptere, very little difference between them is found (*figs. 18 and 19*). Growth rings, such as are reported for *Pterygophora*, were not found in this species of *Alaria*.

The Stipe.—To study the stipe the smallest specimens collected were first used, then some of the larger plants on which gonidiophylls were just beginning to appear, and finally, mature plants.

Mucilage ducts are not present in *Alaria*. In general, three areas of tissue may be made out, *viz.*, epidermis, cortex, and pith, which latter is of the same elliptical shape as in the other kelps (*fig. 11*, *a*, *b*). It is chiefly composed of an interwoven mass of anastomosing filaments, embedded in a gelatinous matrix (*fig. 15*). The cortical area may be divided into an outer and inner layer. The cells of the inner cortex tend rather towards a round shape than a hexagonal (*fig. 14*), but as the outer cortex is reached the cells become polyhedral in shape and gradually smaller in size (*fig. 13*). The epidermal cells appear rectangular in shape. Chloroplasts were found only in the outermost layers of cortex. In a cross-section of a mature stipe, the cells of the outer cortex give the appearance of being radially arranged. This is no doubt due to the radial division

of certain rows of cambial cells, situated between the inner and outer cortex. This difference in outer and inner cortex, caused by this radial growth of the outer cortex, seems to the writer, to account for the growth rings figured by Postels and Ruprecht. Growth in thickness is also due to the activity of these cambial cells.

Young stipes are rather soft, but older ones are quite tough and hard, although in this respect they are comparable to stipes of *Laminaria* rather than to those of *Lessonia* or *Pterygophora*.

The Lamina. — In *Alaria* the lamina is provided with a very distinct midrib, which is practically a flattened extension of the stipe. The lamina proper, may be compared to a flattened expansion of the midrib (*fig. 22*).

As in the stipe, a medullary or pith area is found in the midrib, but no distinction into outer and inner cortex can be made out. In a cross-section the pith area will appear very similar to that of the stipe, except that it is much looser (*fig. 25*) but the cortex will be seen to consist of fairly regular, polyhedral cells of medium size, and tightly packed (*fig. 23*). Chloroplasts seem to be present only in the outermost layers, as in the case of the stipe (*fig. 24*). When a section of the lamina (*fig. 26*) perpendicular to the midrib, and close to it, is examined, it is readily seen that the lamina is morphologically but an expansion of the midrib, for the epidermis and cortex differ from the same areas in the midrib in no respect whatever, but the inner layers of cells gradually become very much elongated and tend to anastomose at their ends. In sections taken parallel to the midrib, and at some distance from it (*fig. 27*) it is seen that practically all the tissue except the epidermis consists of long anastomosing cells which are cut at various angles owing to their position. This portion of the plant is very gelatinous, and as soon as decay sets in bladders of mucilage are formed all over its surface by the decay of the tissue.

The meristem or growing area in *Alaria* is at the junction of the stipe and the lamina. The lamina, therefore, grows at its lower end, and the stipe at its upper end. This is also shown by the fact that the base of the lamina is usually elastic, while the tip, which is older, is more flabby and gelatinous.

The gonidiophylls arise at the upper end of the stipe, just below the meristematic area. They first appear as little conical outgrowths of the stipe, but flatten out very soon (*figs. 4, 5,*

6). The basal portion remains somewhat thicker than the rest, and at its end narrows into a short stalk (*fig. 12*). As the stipe grows from its upper end, more and more gonidiophylls are produced laterally by the activity of the meristem, so that finally from thirty to fifty, with the youngest nearest the base of the lamina, may be present. The stipe, which normally is terete in form, becomes somewhat compressed in the area where the gonidiophylls are situated, but its anatomical characters do not change. The sori cover both surfaces of the gonidiophyll. The paraphyses, found among the gonidangia are much larger than these (*fig. 30*). The gonidangia are club-shaped with a thick base; the paraphyses, on the other hand, are very thin and delicate at their bases but as they reach above the gonidangia they thicken out into a club-shaped upper end which has a large cuticular cap on its upper surface, as in the case of ***Pterygophora***. This cap is lamellate in character. Probably the presence of the paraphyses is a great protection to the gonidangia, both in preventing their being preyed on, and in the gonidia being set free before ripe, by the action of the surf. Mature gonidangia measured from 70 mic. to 100 mic. in length, paraphyses from 150 mic. to 180 mic. in length. The cuticular cap of the paraphyses measured in width from 26 mic. to 33 mic. at the top, and from 14 mic. to 17 mic. thick.

Description of Species.

Alaria nana sp. nov.

Plant rather small, thirty to fifty centimeters long, green to greenish brown in color; stipe rather long (4.5–7 cm. long), firm, elastic, robust, terete; rachis rather long (2–4 cm.), slightly compressed, passing into the midrib gradually at upper end; blade about one sixth as wide as long (6.5–8.5 cm. in widest part), rather thin, elastic, tapering slightly at upper end, midrib prominent, .40–.75 cm. wide, projecting equally on both surfaces, somewhat rectangular in cross-section; gonidiophylls long, narrow, elliptical (6–12 cm. long, .75–1.50 cm. wide), narrowed and thickened at base into a short stalk; rachis bears 25–50 gonidiophylls as lateral outgrowths; fruiting area covering both entire surfaces.

Abundant in very exposed situations, covered only at high tide, but always beaten about by the surf.

Collected at Postelsia point, Minnesota Seaside Station, July–August, 1902.

Summary.

1. *Alaria nana* is one of the smallest Alariæ known, mature plants seldom being longer than 50–70 cm.

2. At the Minnesota Seaside Station it is a surge plant, belonging in the same group as *Lessonia littoralis* and *Postelsia palmæformis*.

3. The holdfast does not show growth rings.

4. The growth of the stipe in thickness is radial, and this difference in growth and shape of the outer and inner cortex, caused by a cambial layer, sometimes gives a ringed appearance to the stipe. Mucilage ducts are not present; cryptostomata were found neither in stipe nor in lamina.

5. The sori occur in large patches on both sides of gonidiophylls produced laterally on the stipe. The paraphyses have large thick mucilaginous caps as in *Lessonia* and *Pterygophora*.

Explanation of Figures.

All drawings, except diagrams of sections were made with the Abbe camera lucida, under an enlargement of × 530, unless otherwise stated.

Plate XXIII.

Postelsia Point at Minnesota Seaside Station — showing *Postelsia palmæformis*, *Alaria* and other surf plants. Photographed by C. J. Hibbard.

Plate XXIV.

Photograph of two mature and fair sized plants, and of three small plantlets, one third natural size. Photographed by C. J. Hibbard.

Plates XXV and XXVI.

1–10. Various young stages of *Alaria* drawn natural size; Figs. 4 and 5 showing very young gonidiophylls; Fig. 9 the gonidiophylls are quite mature.

11. Diagrams of sections of stipe. *a*, transverse section showing different tissue areas; *b*, longitudinal section at base showing origin of secondary hapteres in the cortex and two burrows in the stipe, made by small crustaceans; *e*, epidermis; *c*, cortex; *p*, pith; *x*, burrow of crustacean; *h*, hapteres.

12. Sections of upper portion of stipe (rachis) to show origin of gonidiophylls. *a*, transverse section; *b*, longitudinal section in which the midrib has also been sectioned. Areas indicated as for Fig. 11. *g*, gonidiophyll; *l*, lamina.

13. Cross-section of stipe showing outer cortex and epidermis. The chloroplasts in the cortex are shown.

14. Inner cortex of stipe, cross-section.

15. Pith area of a stipe in cross-section showing the anastomosing cells, embedded in a gelatinous matrix.

16. Epidermis and outer cortex of stipe in longitudinal section.

17. Inner cortex of stipe in longitudinal section.

18. Tip of a haptere of holdfast, longitudinal section.

19. Longitudinal section of haptere from the side.

20. Longitudinal section of stipe at origin of a haptere. *a*, cortex of stipe; *b*, cortex of haptere.

21. Cross-section of a haptere at a branch.

22. Diagram, cross-section of midrib indicating the lamina proper and the tissues of the midrib, $\times$ 10 by measurement.

23. Cortex of midrib in cross-section.

24. Longitudinal section showing epidermis and cortex of midrib.

25. Pith area of midrib in longitudinal section. There is practically no difference whatever between the long and cross-sections, as the anastomosing cells run in all directions.

26. Section of lamina cut perpendicular to and very close to the midrib.

27. Section of lamina cut parallel to the midrib and at a distance from it.

28. Diagram of gonidiophylls, natural size. *a*, large and mature; *b*, before the formation of gonidangia.

29. Cross-section of a young gonidiophyll before the formation of gonidangia.

30. Cross-section of a mature gonidiophyll showing gonidangia and paraphyses.

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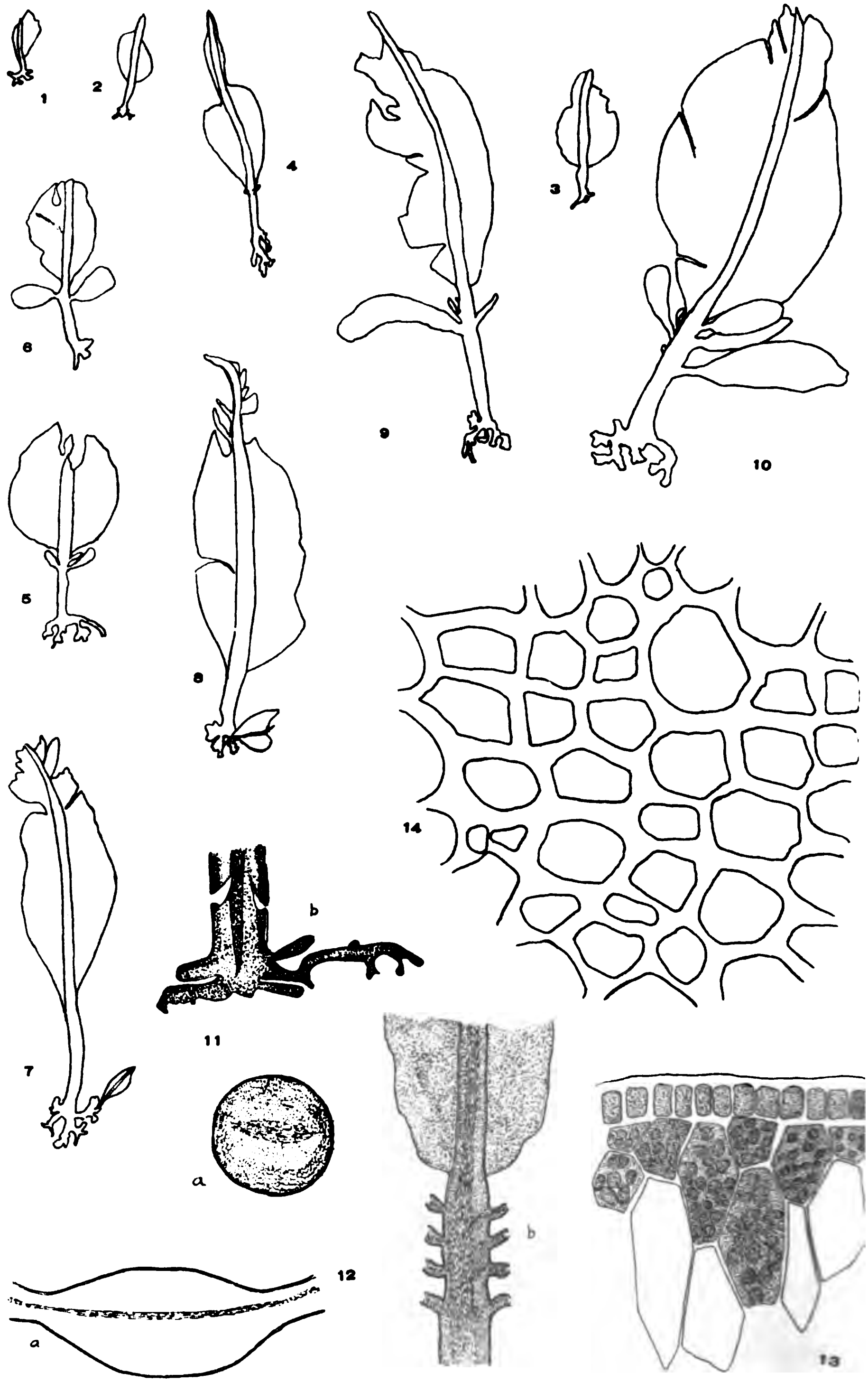
PLATE XXIII.

HELIOTYPE CO., BOSTON.

PLATE XXIV.

HELIOTYPE CO., BOSTON.



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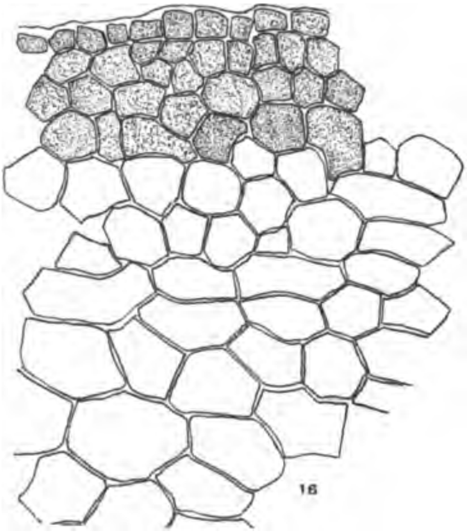

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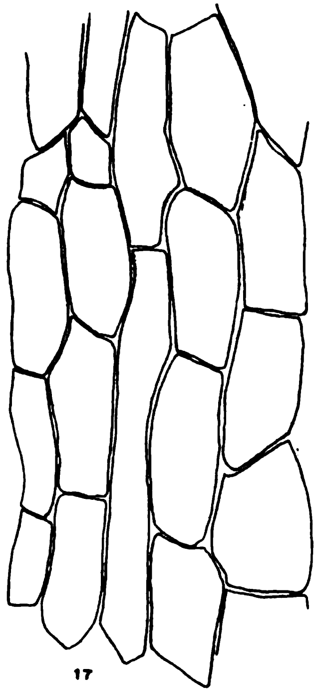

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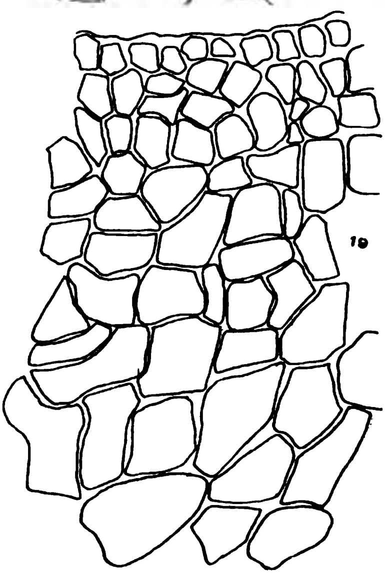

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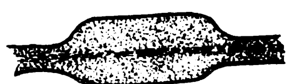

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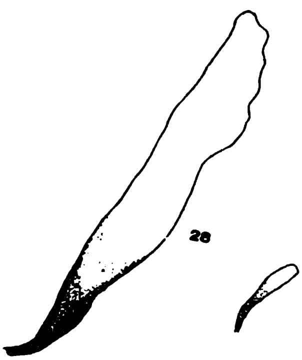

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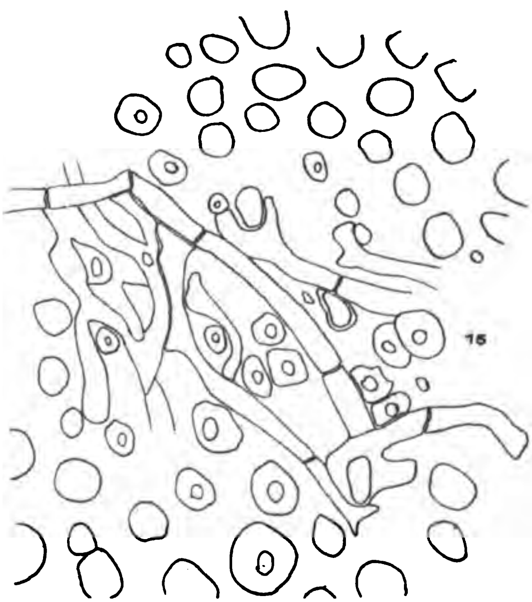

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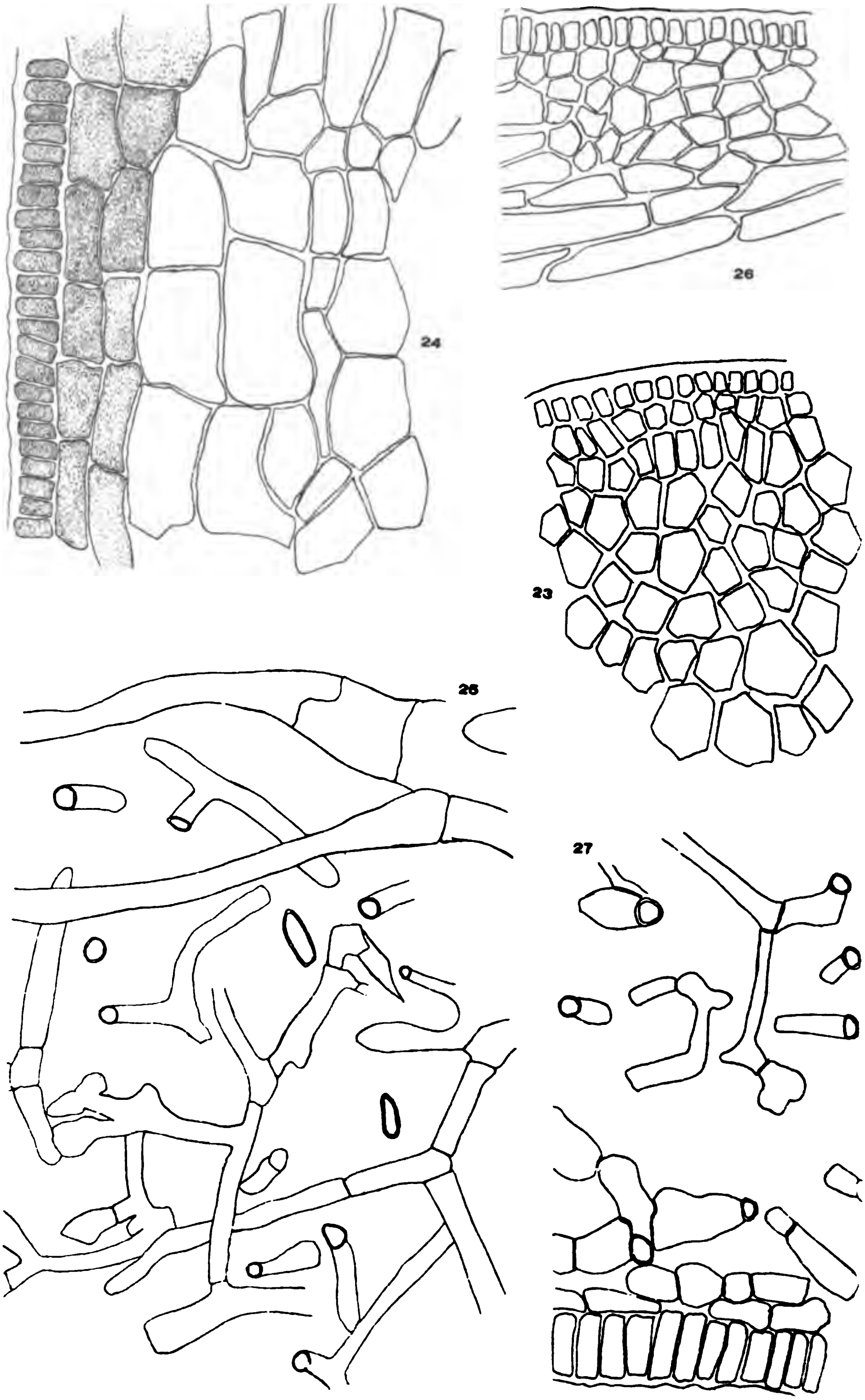

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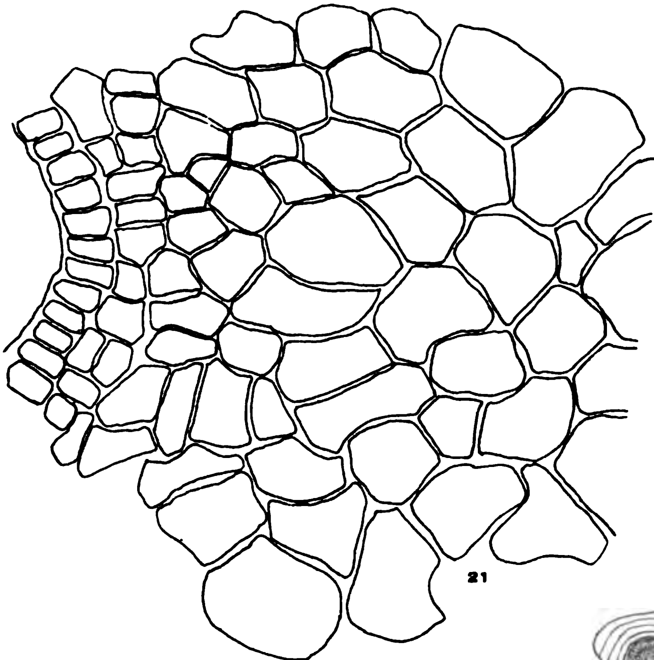

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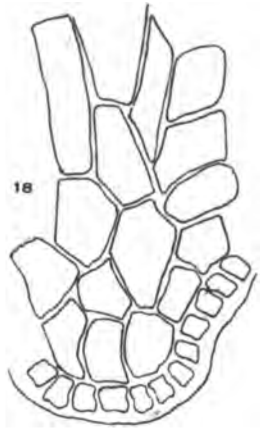

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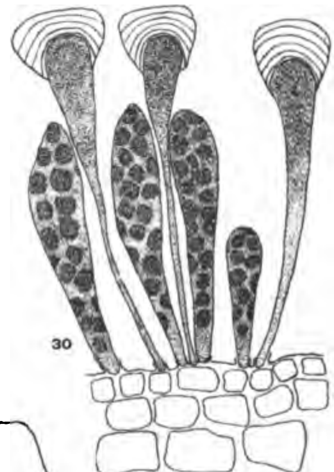

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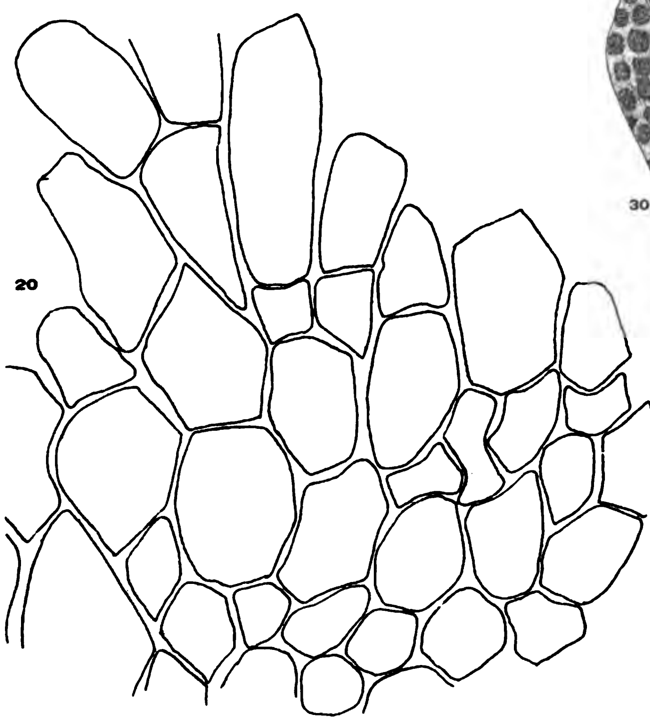

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XVIII. CONTRIBUTIONS TO A KNOWLEDGE OF THE LICHENS OF MINNESOTA.—VII. LICHENS OF THE NORTHERN BOUNDARY.

Bruce Fink.

Considerations of Distribution and Habitat.

During the summer of 1901, the writer spent eleven weeks in field study of lichens for the Minnesota botanical survey, and the following paper is the outcome of that work and subsequent careful study of the material collected. In the study of the *Cladonias*, Dr. E. Wainio has continued his valuable aid till nearly 200 of the Minnesota collections within the genus have passed through his hands, and the work of the whole genus bears the impress of his remarkable knowledge of *Cladonias*. Dr. A. Zahlbrückner has also examined more material since the publication of the last number of this series, but little of his work happens to contribute to the present paper. Moreover, we have found in Dr. T. Hedlund, of Upsala, Sweden, a most excellent helper in the genera *Biatora*, *Lecidea* and *Buellia*, and we are under lasting obligations to him as well as the two men previously named for much aid in the work.

The area considered in the present paper lies along the northern boundary of the state from Warroad eastward by south to Harding, thence southward to Tower. In order to study the flora of a wooded region nearer the northern boundary than Warroad, and at the same time well to the west, Oak island, in Lake of the Woods, and some other islands near by, were studied. The region covered by this paper was selected with a view to obtaining as complete a knowledge as possible of the lichen flora of the extreme northern portion of the state and to supplement the knowledge recorded in the fourth and sixth papers of this series. That the area was well selected for the latter purpose will appear, and its richness is shown in that the list of species and varieties has reached 312 as against 258

for the Lake Superior region. True, the time spent in the territory treated in this paper was nearly twice as long, but after one has been in a limited area for some time, species new to the region do not appear so often; and the larger number of the present list can scarcely be entirely due to the additional time spent, especially when it is remembered that each locality was studied carefully for the sake of distribution rather than merely for species new to the state. However, previous knowledge of the lichens of the state in general and their habitats, gained through long-continued study in the field, made it possible to work more effectually and added considerably to the whole number collected and especially to the number new to the state. So on the whole, it can scarcely be said that the portion of the boundary covered in 1901 is richer in lichen species than the Superior region to the east and southeast. Indeed, the latter region has more diversity as to elevation and temperature with scarcely less as to kinds of trees and other lichen-bearing substrata and should be, and probably is, richer in lichen species. The cold winds along the north shore of lake Superior add materially to the number of northern forms found there, while the influence of the smaller Lake of the Woods and Rainy lake in this respect is less marked. For this reason, again, the lake Superior area should be the more productive of lichen species. Turning to the region whose lichen flora was recorded in the sixth paper of this series, various portions of which lie 50 to 150 miles south of the present area, it may be confidently stated that the former with its 215 recorded forms is considerably poorer than the latter with about one third more recorded. The greater richness in lichen forms in the present region is to be accounted for partly by the fact that there are more rocky substrata and, on the whole, more variety as to substrata. The difference due to presence of rocks is apparent enough, when we record that the present region, like the lake Superior area, has nearly as many forms on rocks as on wood, while the territory farther south has only about half as many. Indeed, some portions of the region now under consideration are doubtless even richer in proportion of rock lichens than the lake Superior area, for in the present paper, a close analysis of the region about Rainy Lake City shows that there are fully ten per cent. more rock than tree lichens. And it may be remarked in passing that the richness in rocky substrata, and more effective

study of them due to long experience, accounts for the fact that this region about Rainy Lake City has furnished a larger number of lichen forms than any other in the state—163.

The collecting stations were Oak island and a few surrounding islands, Warroad, Beaudette, Emo, Koochiching, Rainy Lake City, Kettle falls, Harding and Tower—also a few plants were collected at Le Claire, and on the mainland near Oak island. The islands possess the rock exposures and the hard wood and the coniferous trees as well as the swamps of certain other portions of the area studied and were found to be fully as rich in lichen forms and to present no special distributional peculiarities, except the presence of a somewhat larger per cent. of northern forms. Beaudette was the poorest field visited as regards numbers collected and only furnished 102 forms. This is due to the presence of a vast cedar and tamarack swamp with only a very few hard-wood trees and almost no rocks at all. The swamp is unexcelled in richness of species characteristic of such environment, but comparatively few other lichens are to be found. Warroad presented little better conditions in general, and had it not been for the finding of a single rock exposure one half mile long, toward Roosevelt, would have furnished few more species. This exposure of rock, said tó be thirty miles from other surface rocks, furnished many of the *Biatoras*, *Lecanoras*, *Buellias*, *Cladonias*, *Umbilicarias*, and *Rinodinas* characteristic of such habitat and was surprisingly rich in lichens for such an isolated area of rock. Oak and other neighboring islands furnished 144 forms and Warroad, with the rock exposure mentioned, 130. At Emo on Rainy Lake river, lichen-bearing rock exposures were not numerous, and the number was 128. At Koochiching, at the west end of Rainy lake, rock exposures became more plentiful, and the number reached 145. The number for Rainy Lake City is 163, for Kettle falls 129, for Harding 125 and for Tower 145. At Kettle falls and Harding a special effort was made to study the woods and swamps more especially, so that the work on the rock exposures was not thoroughly covered; and it may be said that the apparent differences in richness in lichens in various portions of the area covered is almost wholly due to differences in amount of rocky substrata, or to amount of work done on them.

One feature of the work that has added to the whole number

of species reported in this paper is that *Cladonias* were sought for with unusual care, knowing that Dr. Wainio would work them out carefully so that a good contribution to Minnesota and North American lichens could be thus made. Also a number of *Buellias*, confusingly like *Buellia petræa* (Kbr.) Tuck., were for the first time detected in the field, as well as a number of *Buellias* parasitic on other lichens.

The region furnished many elements of interest similar to those met in the lake Superior region, but these must be passed over lightly to give place to some ecologic considerations. For instance, the succession of lichen forms following fires and preceding arboreous vegetation could be studied most splendidly in the region and constantly tempts one away from a predetermined line of study. The sensitiveness of the *Cladonias* to the effects of sun and wind are very apparent and would furnish an interesting and very instructive field for extended study. The part that lichens play in soil formation may also be most beautifully studied, especially at Rainy Lake City. A mere suggestion of the possibilities in such a study has been given in these studies,* and the subject must be passed over for the present. The succession of species on trees suggested there has since been followed out in the studies of the arboreous formations and will be continued in the present paper. Also a detailed study of distribution within the present area as was presented in the above-cited paper would be instructive, but we can only give a brief statement as to comparative numbers of arctic or subarctic forms. For the lake Superior region, 41 such lichens were recorded.† For the present area, some 27 such lichens were noted. The following is the list, 20 of which marked (C) occur also in the lake Superior territory.

Ramalina pusilla (Prev.) Tuck. C.

Ramalina pusilla (Prev.) Tuck. var. **geniculata** Tuck. C.

Usnea cavernosa Tuck. C.

Peltigera canina (L.) Hoffm. var. **spongiosa** Tuck.

Physcia hispida (Schreb.) Fr. C.

Umbilicaria vellea (L.) Nyl. C.

Umbilicaria hyperborea Hoffm. C.

* Fink, B. Contributions to a Knowledge of the Lichens of Minnesota.—IV. Lichens of the Lake Superior Region. Minn. Bot. Stud., 2: 221. 29 D. 1899.

† Fink, B. *l. c.*, 227–233.

Nephroma lævigatum ACH. var. **parile** NYL. C.
Nephroma tomentosum (HOFFM.) NECK. C.
Lecanora frustulosa (DICKS.) MASS. C.
Lecanora verrucosa (ACH.) LAUR. var. **mutabilis** TH. FR.
Stereocaulon paschale (L.) FR. C.
Stereocaulon tomentosum (FR.) TH. FR.
Cladonia deformis HOFFM. C.
Cladonia digitata (L.) HOFFM. C.
Cladonia amaurocræa (FLK.) SCHAER. C.
Bæomyces æruginosus (SCOP.) DC. C.
Biatora lucida (ACH.) FR. C.
Lecidea lapicida FR. C.
Lecidea platycarpa ACH. C.
Buellia geographica (PERS.) TUCK. C.
Buellia petræa (FLK.) TUCK. C.
Buellia petræa (FLK.) TUCK. var. **montagnæi** TUCK. C.
Buellia badioatra (FLK.) KBR.
Buellia concreta (KBR.) ECK.
Buellia obscurata (ACH.) ECK.
Buellia concentrica (DAV.) FINK.

Inspection of the lists for the two regions involved shows conclusively that the one first studied has a much larger proportion of arctic and subarctic lichen forms; for the proportion is approximately two to one, while the whole number of lichens is considerably smaller. This is what had been anticipated, though areas some fifty miles farther north were reached in the study of the region treated in the present paper. As was stated in the paper cited above,* it was not expected that the northwestern part of the state would give a large number of northern lichens, and the number found is larger considerably than was supposed to exist when the study was begun. Professor Conway MacMillan † has noted the difference between the spermaphytic floras of the two regions; and we conclude from his statements that the post-glacial change in flora has been more rapid for the higher plants than for lichens, and that the lichen flora of the region about Lake of the Woods contains a larger proportion of northern forms than does the spermaphytic flora of the same area.

* Fink, B. l. c., 233-234.

† MacMillan, C. Observations on the distribution of plants along the shore at Lake of the Woods. Minn. Bot. Stud. 1: 954. 1897.

Avoiding unnecessary detailed statement, it may be briefly stated that the present list adds 64 lichen species and varieties to the flora of the state, and with about 20 Minnesota lichens yet undetermined, brings the whole number of lichens for the state very near to the 500 mark set by the State Botanist a few years ago.* The estimate seemed high at the time, but a month's search for new species in northern Minnesota would pass it considerably; and it is now safe to increase the estimate to 700, a number which may not be reached, though there is little doubt that many lichen forms exist in the state. Of the 64 one is new, and 13 more are new to North America. Besides these, several are not yet determined. The northern portion of the state has now been studied more than parts farther south, but this part of Minnesota is by far the most interesting to the lichenist and would surely still yield more new material than most areas farther south in the state.

All of the northern boundary has been studied more or less, except the region in the Red river valley, which is very poor in lichens; and as other features of origin and distribution were considered in the work to the eastward of the present area in 1897, it is the more fitting that the formations should receive special attention in this paper. The two areas are somewhat similar as to lichen floras, and the two papers will thus supplement each other, the present bringing out features which constantly obtruded themselves in 1897, but which could not receive attention.

Before passing to the lichen societies of the region, some general statement as to substrata will be in order. No limestones were seen during the summer, all of the rocks being those of the Archæan or Algonkian groups. To the westward cedar and tamarack swamps abounded, especially the former. Hard-wood trees were found here, but they are not numerous, and attention was given largely to the swamps, which furnish the most interesting field in Minnesota for the lichenist. Passing eastward and southward fewer and smaller swamps were found, and more rock exposures. A great variety of substrata was investigated, as will appear in passing in order the large number of formations to follow. A matter of special interest was the opportunity offered of studying further the swamp formations previously investigated farther south. Also, time was

* MacMillan, C. Minnesota Plant Life, 95. 1899.

found for the first time to give detailed attention to the lichen communities of wet rocks and to the poplar tree formations about Lake of the Woods. The *Umbilicaria* formations also were studied ecologically for the first time, and the *Cladonias* of humus over rocks as well. Finally, a brief mention of the unusually large number of lichens found living parasitically on other lichens is in order.

In passing to the consideration of formations, it may be said that, as in the previous studies of this series, in covering so large a region in limited time and making extensive collections and taking notes on ecologic distribution at the same time, it was not found possible to give attention to other than the more general ecological considerations. Some general statement may be made of various adaptations noted and not previously reported, and some of them must be taken as merely suggestive and as yet little more than mere guesses thrown out with the hope that others may be inclined to study some of them more in detail. First of all, it is certain that, in many of the fruticose lichens as the *Ramalinas*, some *Cetrarias*, *Evernias*, *Usneas*, *Stereocaulons* and *Cladonias*, there is in dry weather a drawing together of branches as if to lessen exposure to wind and lessen transpiration of moisture. The same seems true of the crisping and bringing together of lobes in many of the foliose species in dry weather or the dry portion of a day. This may be seen in *Peltigeras*, some foliose *Cetrarias* and certain *Nephromas*, *Leptogiums*, *Collemas* and *Theloschistes*. The writer has made some preliminary studies on *Peltigera* and *Ramalina* and is convinced that some species of the former genus are as responsive to moisture relations as are certain seed-plants as *Oxalis* and many legumes to light and temperature. Also he believes that many lichens are quite responsive to light and temperature conditions in passing from their moist flexible state to the dry and fixed condition. There is here a most excellent field of work open to any one who may wish to cultivate it. But such problems are to be studied at leisure and not in the hurry of a general survey of many lichen societies. Then, too, there is the hairiness or ciliate condition of a number of the lichens of northern Minnesota. This finds expression sometimes as strong rhizoids on the lower surface as in the *Peltigeras*, in the smaller ones forming a dense nap on the lower surface as in *Nephromas* and in

the same sort of development on the upper surface as in the trichomatic hyphæ of some *Peltigeras*. There is more or less of the same development of such structures in other genera as in *Physcia ciliaris* (L.) DC. and *P. hispida* (Schreb.) Tuck. and even in some *Cladonias*, though usually quite overlooked in the last. These structures may be protective in part, are surely related to some extent to moisture conditions, but they seem to be better developed as a whole toward the north and no doubt have a temperature relation as well. Thus when we add the many adaptations in thallus structure, which have been dwelt on in the last paper of this series and will receive attention in the following pages, and which are surely more than purely mechanical adaptations, it becomes very apparent that to dismiss lichens ecologically, as is sometimes done, with the mere statement that they can endure complete desiccation and therefore have and need no special adaptations is quite erroneous. That they can endure great desiccation is to be admitted; but since they have the unusual power of absorbing moisture directly from the atmosphere, it is doubtful whether the drying process often goes so far as has been commonly supposed. However much of drying the lichens may be able to endure, we are convinced that the condition is unfavorable to them and that, like xerophytes in general, they show certain structural adaptations, and these we shall consider as well as may be done in a general survey. Moreover, in this survey of a large region involving many conditions, a large number of geological, climatic, physiographic, hydrodynamic, biotic, general atmospheric and even some of the more important edaphic factors could not receive the attention deserved.

Beginning with the previously studied and better known formations and passing to the less known and finally to a few here introduced for the first time, we may take first the following:

Lecanora Formation of Exposed (Usually Horizontal) Rocks. (Rainy Lake City.)

Parmelia saxatilis (L.) Fr. var. **panniformis** Ach.
Parmelia olivacea (L.) Ach. var. **prolixa** Ach.
Parmelia conspersa (Ehrh.) Ach.
Physcia stellaris (L.) Tuck. var. **apiola** Nyl.
Physcia cæsia (Hoffm.) Nyl.
Placodium elegans (Link.) DC.

Placodium cinnabarrinum (Ach.) Anz.
Placodium citrinum (Hoffm.) Light.
Placodium cerinum (Hedw.) Naeg. and Hepp. var. **sideritis** Tuck.
Placodium aurantiacum (Light.) Naeg. and Hepp.
Placodium vitellinum (Ehrh.) Naeg. and Hepp. var. **aurellum** Ach.
Lecanora rubina (Vill.) Ach.
Lecanora rubina (Vill.) Ach. var. **heteromorpha** Ach.
Lecanora muralis (Schreb.) Schaer. var. **saxicola** Schaer.
Lecanora frustulosa (Dicks.) Mass.
Lecanora varia (Ehrh.) Nyl.
Lecanora cinerea (L.) Sommerf.
Lecanora cinerea (L.) Sommerf. var. **lævata** Fr.
Lecanora fuscata (Schrad.) Th. Fr.
Rinodina oreina (Ach.) Mass.
Rinodina lecanorina Mass.
Urceolaria scruposa (L.) Nyl.
Lecidea lapicida Fr.
Buellia concreta (Kbr.) Eck.
Buellia petræa (Flk.) Tuck.
Buellia petræa (Flk.) Tuck. var. **montagnæi** Tuck.

Similar formations were found well developed in other places, as on Oak island, at Kettle falls, and at Tower, where they were especially well represented. Turning to the similar formation recorded for Granite falls in the fifth paper of this series, it appears that there is the usual marked resemblance in the formations of the similar substrata in remotely separate portions of the state. The genera are the same practically and the species remarkably near so, except for the presence in the above formation of a few more northern forms of *Lecidea* and *Buellia*. By adding *Biatora rufonigra* Tuck. from the similar formation at Kettle falls and the *Endocarpon* from the one at Emo, the genera would be identical in the two formations. However, it would be accidental rather than otherwise if exactly the same forms existed in two distinct formations even when much less remote. The northern *Buellia obscurata* (Ach.) Eck. occurs in the like formation at Kettle falls, and passing to the Oak island region, where were met more arctic and subarctic lichens than anywhere else on account of more northern location, and yet more because of the influence of the larger Lake of the Woods,

we find in the formations on some of the islands the northern *Lecidea goniophila* Kbr., *Lecidea platycarpa* Ach., *Buellia badioatra* (Fl.) Kbr. and *Buellia geographica* (L.) Th. Fr.

As to the structural adaptations, they are very apparent. First of all there is not a very large or loosely adnate lichen in the society, much less a fruticose form. The two varieties of *Parmelia* are forms having rather more closely adnate thalli and thicker cortex than their relatives in the same species on trees or more shaded rocks. Also the third *Parmelia* is rather smaller and more closely adnate than its near relative, *Parmelia caperata* (L.), Ach., more commonly found on trees. Careful comparative studies of the microscopic characters of these last two have not been made, but such study would doubtless show that the exposed-rock-inhabiting species has a cortex better adapted to exposure. An adaptation in all the closely adnate thalli of the formation is protection from wind and consequent more rapid transpiration and even destruction by being blown loose, which would surely come to the larger fruticose forms as certain *Cladonias* in such positions. On the whole, the larger the thallus of a given lichen in the present formation, the better the cortex, the larger ones commonly having good cortex both above and below, and the smaller usually at least a good upper cortex. More definite statements regarding the structure of the thalli of the lichens in the various genera may be found in certain portions of the last paper of this series and need not be repeated here.

We may now pass most appropriately to the consideration of another lithophytic lichen formation, designated as follows:

Mixed Lichen Formation of Shaded Rocks (Rainy Lake City).

A. *Naturally belonging to the rocks.*

Ramalina polymorpha (Ach.) Tuck.
Ramalina calicaris (L.) Fr. var. **farinacea** Schaer.
Theloschistes lychneus (Nyl.) Tuck.?
Parmelia perlata (L.) Ach.
Parmelia perlata (L.) Ach. var. **ciliata** (DC.) Nyl.
Physcia obscura (Ehrh.) Nyl. var. **endochrysea** Nyl.?
Sticta quercizans (Michx.) Ach.?
Pannaria microphylla (Sw.) Delis.

Collema flaccidum ACH.
Leptogium lacerum (SW.) FR.
Leptogium tremelloides (L.) FR.
Cladonia cæspiticia (PERS.) FLK.
Bæomyces byssoides (L.) SCHAER.
Biatora lucida (ACH.) FR.

B. *Probably migrated from trees near by.*

Parmelia conspurcata (SCHAER.) WAINIO.
Parmelia physodes (L.) ACH.?
Parmelia borreri TURN. var. **rudecta** TUCK.
Parmelia caperata (L.) ACH.
Physcia stellaris (L.) TUCK.
Physcia speciosa (ACH.) NYL.
Physcia hispida (FR.) TUCK.?
Physcia obscura (EHRH.) NYL.
Nephroma tomentosum (HOFFM.) KBR.?

C. *Species that have migrated from earth.*

Peltigera canina (L.) HOFFM.
Peltigera aphthosa (L.) HOFFM.

Similar formations were met elsewhere during the summers' work, but were not carefully studied and would add nothing to the list recorded above. The formation listed above lies along some perpendicular rock exposure some twenty rods back from the shore line and about a half mile from Rainy Lake City, while the exposed rock formations, like the one first recorded in this paper, may be found at many points along the lake shore, and at a few places back from the shore, but here usually poorly developed because of recent fires or the presence of trees over the rocks. The two formations recorded above are the extremes for the region, and every gradation between the pure exposed rock lichen formation and the mixed one in more shaded spots may be found. The society listed last above was found on rocks for the most part perpendicular, and it has been thought best to give later another formation found here and elsewhere on more horizontal rocks, more covered with humus. This formation will be recorded as a *Cladonia rangiferina formation of humus-covered horizontal rocks.* Attention is directed to it here lest those familiar with the luxuriance of the *Cladonias* of the region and not so familiar with our analysis should wonder why these

plants are excluded from the present formation. Indeed, *Cladonias* were almost entirely absent from the present formation, though the *Cladonia* society named above was fairly well developed on more horizontal rocks a few rods away. It is needless to say that these two lichen societies also grade into each other in the most confusing manner in some areas.

Some of the plants of the formation seem, in the region at least, to belong indifferently to the trees or to the rocks. These have been designated (?) in the above list. As may be inferred from statements above, tension lines are very apparent between the present formation and others of the surrounding earth and rocks, and it is a noticeable fact that the wandering of lichen floral elements is almost always from trees to the shaded rocks. In this region, devoid of limestone, *Pannaria languinosa* (Ach.) Kbr. is frequently present in such formations and was frequently seen in other similar formations near by and elsewhere.

If we compare again the present formation with the similar one at Granite falls, even though the trees surrounding the former are partly coniferous and the latter hard-woods, we note almost as much similarity in the two remote societies as was seen in the exposed rock formations of the same localities. No special mention need be made of the resemblances, as a glance at the two lists will reveal them forcibly enough. One striking difference, however, is the absence of the *Endocarpons*, *Verrucarias* and *Staurotheles*. If present, they were forgotten in the special study and not collected on the spot because abundant at the water's edge a few rods away. Moreover, we are now in a lake region where these plants, if in the present formation at all, would be there by chance and out of their more natural habitat on the moist rocks at the shore line. They will be found recorded below in what we have seen fit to designate the *amphibious angiocarpic wet rock lichen formation*, better studied at Tower.

Passing to the matter of adaptations, they may be summed up shortly. The plants are larger forms than those of the first formation above and as a rule have well-developed cortex on both sides of the foliose thallus. Many of them are plants which may grow on trees or earth and in less shaded stations, and the society is by no means so strictly lithophytic as the one of the exposed rocks. On the whole, the *Ramalinas*, the *Collema* and the *Leptogiums* are the most typical members of the society.

The first genus shows a good cortex on all sides of the fruticose thalli, but the plants, rising from the substratum, need such protection even in the shaded habitat. The *Collema* of course has no cortex and is a shade and moisture loving plant *par excellence.* The members of the last genus have a poorly developed cortex and are nearly as strictly ombrophytic as the *Collema.* The *Cladonia* and the *Bæomyces* show podetia protected by a good cortex, so that they rise easily from the substratum. The single *Biatora* has a thallus consisting merely of a tangle of epilithic algal cells and fungal hyphæ and is as strictly confined to shaded habitats as is *Pannaria languinosa* (Ach.) Kbr. The *Peltigeras* have a good cortex above, and the abundant rhizoids of lower layer horizontally disposed hyphæ serve well enough for protection to the lower side of such shade or moisture loving plants as the members of the genus commonly are. Other members of the formation need no further mention than the statement already made that they have a good cortex on both sides and are not so strictly ombrophytic.

In considering the more familiar formations first, we shall now pass from the rock lichens to those of trees, and these may be passed over with a brief statement. These formations have been duly considered in the fifth and sixth papers of this series, and nothing would be added by giving space to long lists of species; nor is it thought necessary to repeat the statements regarding adaptations as already given in the sixth paper. Briefly then, regarding the *Parmelia formation of trees with rough bark* as studied in a number of localities, the only new plants of such formations noted in any of the localities were *Ramalina pusilla* (Prev.) Tuck., *Cetraria juniperina* (L.) Ach. var. *pinastri* Ach., *Alectoria jubata* (L.) Tuck. and *Parmelia conspurcata* (Schaer.) Wainio. These are partly plants not found in the regions farther south, too rare to include in the formations or found growing in slightly different relations and not included. Reviewing next in order the *Pyrenula formation of trees with smooth bark*, the additional plants are *Lecanora variolascens* (Fr.) Nyl., *Lecanora verrucosa* (Ach.) Laur. var. *mutabilis* Th. Fr., *Biatora varians* (Ach.) Tuck. and *Biatora atropurpurea* (Mass.) Hepp.; and all of these plants were found in one or both of the regions discussed in the papers mentioned above, but either were rare or not present at the places where the formations were studied. These formations were noticed more at Emo than

elsewhere in the region covered in the present paper, partly because well developed there and in part also because there was less else of special interest there to claim attention. Hard woods were sought for these studies, but the influence of conifers is seen in the nature of the four species added above for the rough-bark formations of the present region.

Favorable opportunity for study of the lichens of pine trees was not found till Rainy Lake City was reached. Here the further investigation of the *Usnei formation of the pines* begun at Red Lake and Bemidji and recorded in the sixth report was continued, as it was thought to be desirable to record the formation from a locality somewhat removed from these two. Here again the usual remarkable similarity was found, and in the formation of conspicuous and well-known lichens, none new to the state or to the formation were found. However, *Theloschistes chrysopthalmus* (L.) Norm, found in both of the other two localities, was wanting and *Parmelia saxatilis* (L.) Fr. and *Parmelia caperata* (L.) Ach., doubtless occasionally occurring on the pines at Red Lake and Bemidji, but not considered a conspicuous part of the formation, were at Rainy Lake City, so commonly associated with the other plants of the society that they could not be overlooked as forming a conspicuous portion of it. Again, since it is intended to avoid repetition and make the papers of the series supplement each other as much as possible, it is not thought necessary to reproduce either the list of species or the statement of adaptations as given in the sixth report.

The next in order is a *Cladonia* formation, and the one found at Emo is sufficiently different from the similar ones recorded in the fifth and sixth reports for Mankato and Bemidji, so that it seems desirable to give a list of species as follows:

CLADONIA LICHEN FORMATION OF ROTTEN WOOD (EMO).

Cladonia fimbriata (L.) FR. var. **coniocræa** (FLK.) WAINIO.
Cladonia gracilis (L.) WILLD. (and two varieties).
Cladonia verticillata HOFFM.
Cladonia pyxidata (L.) FR. var. **neglecta** (FLK.) MASS.
Cladonia pityrea (FLK.) FR. (two varieties).
Cladonia squamosa (SCOP.) HOFFM.
Cladonia cristatella TUCK.
Bæomyces æruginosus (SCOP.) NYL.

A noticeable difference between the present list and those for the two areas named above is the omission of the *Peltigeras* from the present one. Both of the forms of the genus recorded in the previous reports were seen frequently enough at Emo and at other points where the formation was noted with less care, but they were seldom seen on rotten wood. Some of the apparent difference in the three lists as to the forms of *Cladonia* is due to the adoption of Dr. Wainio's nomenclature, but *Cladonia squamosa* (Scop.) Hoffm. and the two forms of *Cladonia pityrea* (Flk.) Fr. are additions. The last lichen of the above list is a species not known farther south, as is also the *Cladonia* named last above. Inspection of the three lists will show that there is more than the usual amount of variation in these formations in different regions. The adaptations have received sufficient attention in the sixth report.

Passing now to the swamp formations, we may best record two that are somewhat closely related and sometimes confusingly intermingled. These are the formations of the tamaracks and those of the cedars of the swamps. The first recorded below was studied at Henning and the second at Bemidji, and the formations as observed at those places have been recorded in the sixth report of this series.

USNEA LICHEN FORMATION OF TAMARACKS IN SWAMPS (BEAUDETTE).

Cetraria ciliaris (ACH.) TUCK.
Cetraria juniperina (L.) ACH. var. **pinastri** ACH.
Evernia prunastri (L.) ACH.
Usnea barbata (L.) FR. var. **florida** FR.
Usnea barbata (L.) FR. var. **ceratina** SCHAER.
Usnea cavernosa TUCK.
Alectoria jubata (L.) TUCK. var. **chalybeiformis** ACH.
Parmelia physodes (L.) ACH.
Parmelia olivacea (L.) ACH.
Physcia hispida (ACH.) TUCK.
Ramalina pusilla (PREV.) TUCK.

The above formation was studied on a few tamarack trees of a swamp some distance from Beaudette along the railroad that was being surveyed during the summer and on the Canadian side. The trees were surrounded by cedars, and most of the lichens of the above list were found on the cedars also. In short, most

lichens of cedars and tamaracks like the cedars better, but those of the above list are those that are at least fully as much inclined to the tamaracks, and may be regarded as making up a definite formation in pure tamarack swamps; though it must be admitted that the results are most confusing in the presence of cedars, and indeed so much so that I am inclined to believe that, had I first encountered a mixed swamp for study, I might have seen a cedar-tamarack formation instead of two distinct ones. However, the conclusion that there are two is secure, and it may be remarked in passing that for purposes of study of either of the formations it matters little whether one enters one of the vast swamp regions or a small swamp a few rods in diameter. And, indeed, one is surer of his results if he confines himself to what may be called a small society rather than to attempt the study of a widely extended formation. In the small swamp one is impressed with the fact that the characteristic lichens of the formation seem to have entered from all sides from less favorable habitats or substrata, and they are more easily studied on the small area. And the species may be found in nearly as large numbers in the small as in the large swamp. It may well be added in passing that the above principle in the study of lichen societies has impressed the writer in the investigation of lichen formations in general, and it usually seems to matter little whether the small formation is near other similar ones or far removed and isolated. The adaptations of the above recorded formation have been dwelt upon in the sixth report and need not be repeated here. So we may pass at once to the formation of the swamp cedars.

STICTA PULMONARIA LICHEN FORMATION OF CEDAR SWAMPS (BOUCHERVILLE).

Cetraria ciliaris (ACH.) TUCK.
Cetraria lacunosa ACH.
Cetraria aurescens TUCK.
Parmelia borreri TUCK. var. **rudecta** TUCK.
Pyxine sorediata FR.
Sticta pulmonaria (L.) ACH.
Sticta amplissima (SCOP.) MASS.
Sticta fuliginosa (DICKS.) ACH.
Nephroma helveticum ACH.
Nephroma lævigatum ACH.

Pannaria rubiginosa (THUNB.) DELIS.
Pannaria rubiginosa (THUNB.) DELIS. var. **conioplea** FR.
Pannaria leucosticta TUCK.
Leptogium myochroum (EHRH.) TUCK.
Leptogium pulchellum (ACH.) TUCK.
Lecanora subfusca (L.) ACH. var. **allophana** ACH.
Lecanora pallescens (L.) SCHAER.
Pertusaria communis DC.

This swamp at Boucherville was studied on one of the trips out from Emo, a few miles farther up Rainy river. The landing called Boucherville is on the Canadian side, and the swamp lies a few rods west of the few houses and along the river bank. Most of the surrounding land is now cultivated; and what were the original surroundings was difficult to determine in the short time at hand, nor was note made of conditions farther down stream. But to all intents we entered a small cedar swamp and there found in fifteen minutes all of the plants of the above formation, which is the most characteristic one yet found on the cedars. The number of plants is the largest seen in such formations in any one place, but all of the genera, except *Pyxine*, and about two thirds of the species may be found in almost any cedar swamp of the region. In the present formation the *Cetrarias* and *Pannarias* are as characteristic of the society as any of the *Stictas*. *Cetraria lacunosa* Ach. and *Pannaria rubiginosa* (Thunb.) Delis. are especially fond of the cedars, and the last three plants of the list are scarcely less so. In the presence of tamaracks the formation is still reasonably distinct, though it must not be understood that there are here recorded all the lichens that occur on cedars; and when tamaracks are near by or mixed with the cedars, members of the last formation come in and confuse to some extent. The pecular thing is that while the lichens of the tamaracks wander to the cedars in mixed swamps, those more characteristic of the cedars are very seldom seen on the tamaracks. An attempt was made at the similar formation at Bemidji. The further study confirms the existence of such formations, but also a comparison of the two lists proves that the first results were very meager. The *Pannarias* and *Leptogiums*, as is well known, like moist and shaded habitats, and are possibly quite as numerous on certain hard-wood trees when mixed with the cedars in swamps. This was noted especially in swamps about

Koochiching, where *Sticta amplissima* (Scop.) Mass. was also frequent on hard-woods of the swamps. The other members of the formation are in the main at least plants frequently seen on higher ground and on other trees, and at present we can only say as to adaptation that for some reason they find the cedars to be especially congenial hosts, or are perhaps attracted also in part by moisture. The discussion of the formation must not be closed without mentioning two lichen parasites almost always found in the formation on the *Parmelia* and another frequently seen on the *Pertusaria*, all helping to form one of the most fascinating lichen communities known to the writer. The two on the *Parmelia* are *Biatora oxyspora* (Tul.) Tuck. and *Buellia parmeliarum* (Sommerf.) Tuck. The one on the *Pertusaria* is *Calicium turbinatum* Pers.

There are yet two lichen societies of the swamps to record, following out observations begun at Henning and Bemidji. These were in those places noted especially in the more common tamarack swamps, but in the present region the cedars are more common and very similar societies were detected under them and on the dead branches. Possibly it may appear to one not especially familiar with lichens that we are doing violence to the conception of plant associations in general in the formation of some of our lichen societies in the midst of other plants and also in making so many subdivisions. However, the establishment of the conception of an exclusively licheno-series of formations has seemed to be the only way to deal with the problems at hand successfully. Possibly our last formation above and the next two below, for the sake of less subdivision, might be regarded as different strata of a single society; but the fact remains that the presence of the plant assemblage of the list last above seems more dependent upon the occupation of the swamp by cedars, while those of the two below are dependent in the first instance mainly upon the presence of dead coniferous wood and in the second upon the moisture of the soil and more or less shade furnished by the trees. The method pursued has at least seemed best in working out results in the swamps as well as elsewhere, and it appears to the writer that a very similar one, though perhaps couched in different terms and having less of subdivision, must be followed by any one who attempts to deal with the ecologic distribution of the lichens of a region thoroughly. The two remaining formations of

the cedar swamps of the region will now be recorded and discussed in order.

CALICIUM LICHEN FORMATION OF OLD LOGS AND STUMPS IN CEDAR SWAMPS (BEAUDETTE).

Lecanora pallida (SCHREB.) SCHAER.
Biatora turgidula (FR.) NYL.
Calicium trichiale ACH. var. **cinereum** NYL.
Calicium phæocephalum (TURN.) TURN. and BORR.
Calicium parietinum ACH.

Such formations were noted at a number of places and were found to vary considerably. Yet there are always the *Caliciums* and a number of them at one place. However, it is not easy to distinguish several of the species macroscopically, and one can not be at all certain that he has not collected the same over and over and left some untouched, even after the most careful work. The *Cladonias* listed in the formation from Henning in the sixth paper of the present series did not, under the cedars, seem to form an essential portion of the formation and were omitted, though some were present and might be regarded as a basal stratum. As to adaptations, nothing need be added to what was given in the last paper of this series.

Several rare *Biatoras* were noted on the cedars, but so little was known of them that their relation to the formation could not be successfully studied at any one place. Also, the *Caliciums* of the upland woods were not successfully studied as attention was directed to the less well known and better developed formations of the cedar swamps. There is no doubt that at least the *Calicei formation of dead wood*, worked out in the fifth and sixth reports, exists in the region, but no satisfactory results were obtained.

The last formation of the cedar swamps was studied previously at Bemidji and several other localities in tamarack swamps and has received the following name, though subsequent study makes the variety on which it is based somewhat uncertain, and the work in the area now under consideration shows this variety to be more rare than was previously supposed.

PELTIGERA CANINA LEUCORRHIZA LICHEN FORMATION OF EARTH IN CEDAR SWAMPS (OAK ISLAND).

Peltigera canina (L.) HOFFM.
Peltigera canina (L.) HOFFM. var. **leucorrhiza** FLK.

Peltigera canina (L.) HOFFM. var. **spongiosa** TUCK.
Peltigera aphthosa (L.) HOFFM.
Peltigera horizontalis (L.) HOFFM.
Cladonia pyxidata (L.) FR. var. **neglecta** (FLK.) MASS.
Cladonia gracilis (L.) NYL. (a variety not carefully noted).
Cladonia furcata (HUDS.) FR.?

The *Cladonias* previously included in such formations seemed here also to form an essential though plainly subordinate portion of it and have been retained. The *Peltigeras* are the largest forms known to the writer, and, in their wet and more or less shaded habitat, reach unusual size. Three or four of them may be found in almost any such swamp of the region, and detailed statement as to which occur in a given swamp would be of little or no value. The adaptations were briefly summed up in the last paper of this series, and nothing need be added, except to state that lying prostrate on the moist earth or mosses of the swamp and partly out of reach of winds, the plants have an abundance of moisture, seldom being dry as their related forms on higher ground, and hence the usual luxuriance.

The last of the previously recorded formations to be noted is the *Biatora lichen formation of mosses*. This was found well developed at Beaudette, Koochiching and Rainy Lake City. The last locality furnished all of the species recorded for Bemidji in the last paper of this series, and *Biatora sanguineoatra* Fr. may be added, and each of the other two localities showed three of them. The adaptations have been discussed previously, nor is it necessary to reproduce the list of five species.

Proceeding to formations not previously recorded, first may be considered the following:

POPULUS LICHEN FORMATION (WARROAD).

Ramalina calicaris (L.) FR. var. **fastigiata** FR.
Cetraria ciliaris (ACH.) TUCK.
Evernia prunastri (L.) ACH.
Usnea barbata (L.) FR. var. **florida** FR.
Theloschistes polycarpus (EHRH.) TUCK.
Parmelia tiliacea (HOFFM.) NECK.
Parmelia saxatilis (L.) FR.
Parmelia olivacea (L.) ACH.
Parmelia conspurcata (SCHAER.) WAINIO.
Physcia stellaris (L.) TUCK.

Physcia hispida (Fr.) Tuck.
Physcia obscura (Ehrh.) Nyl.
Placodium cerinum (Hedw.) Naeg. and Hepp.
Lecanora varia (Ehrh.) Nyl.
Lecanora variolascens (Fr.) Nyl.
Rinodina sophodes (Ach.) Nyl.
Biatora mixta (Fr.)
Biatora atropurpurea (Mass.) Hepp.
Arthonia patellulata Nyl.
Pyrenula leucoplaca (Wahl.) Kbr.

The formation varies with the age of the poplars, from one having more of the crustose lichen species to one having a larger proportion of foliose species. It has been noted frequently in various portions of northern Minnesota, but has not been carefully studied elsewhere. Enough has been noted, however, to know that such a lichen society exists in many places in northern Minnesota and does not differ greatly from the above. Though small and inconspicuous, the last four lichens are decidedly the most characteristic of the formation. Yet the *Rinodina*, the *Placodium* and some of the foliose species are quite partial to the poplars wherever found. Of these foliose forms, *Physcia stellaris* (L.), *Theloschistes polycarpus* (Ehrh.) Tuck. and perhaps *Parmelia olivacea* (L.) Ach. are most constant on the poplars. The adaptations are obviously those of the formations of trees with smooth or rough bark as already given and need not be restated here.

The next to be introduced is a *Cladonia* formation and may be designated as follows:

CLADONIA LICHEN FORMATION OF HUMUS-COVERED ROCKS (RAINY LAKE CITY).

Cladonia rangiferina (L.) Web.
Cladonia coccifera (L.) Willd.
Cladonia amaurocræa (Flk.) Schaer.
Cladonia uncialis (L.) Web.
Cladonia furcata (Ach.) Schrad. (forms of).
Cladonia cenotea (Ach.) Schaer.
Cladonia turgida (Ehrh.) Hoffm.
Cladonia cariosa (Ach.) Spreng.
Cladonia gracilis (L.) Willd. (form of).
Cladonia degenerans (Flk.) Spreng.

Cladonia verticillata HOFFM.
Cladonia pyxidata (L.) FR. var. **neglecta** (FLK.) MASS.
Cladonia cristatella TUCK.
Cladonia fimbriata (L.) FR. (forms of).
Cladonia decorticata (FLK.) SPRENG.
Peltigera malacea (ACH.) FR.
Peltigera canina (L.) HOFFM.

This lichen formation is a very common one in northern Minnesota, and as large an assemblage of species as that given above may frequently be seen on a few square feet of the humus-covered rocks. We have purposely omitted a number of rarer forms seen in the present formation and have not given the varieties of several of the species of *Cladonia*. The formation is very similar to the *Cladonia-Peltigera formation of shaded earth* as recorded for Bemidji in the last report of this series, and the adaptations there stated need not be introduced here. These formations are also almost identical with the *talus Cladonia formations* as presented by the writer in the Botanical Gazette.* As there shown, these formations vary according to amount of humus, age and kind of trees and other factors which can not be considered here. According to various conditions, the present formations may tend toward the larger *Cladonia rangiferina* or the smaller *Cladonia gracilis* formations of the talus, and may pass into the one or the other. *Stereocaulon paschale* (L.) Fr., *Cladonia alpestris* (L.) Rabenh. and *Cladonia sylvatica* (L.) Hoffm. are species usually seen, but which did not appear in the society studied at Rainy Lake City. Like the talus formations, the societies composed of the larger species especially thrive best where protected from wind as well as where shaded more or less. Before leaving this sort of societies we must note that a most interesting formation of the kind was found on one portion of the large isolated rock exposures near Roosevelt previously mentioned. And since such formations have not been extensively recorded and this one is unique because of its isolation, space may well be given to it as follows.

CLADONIA LICHEN FORMATION OF HUMUS-COVERED ROCKS (ROOSEVELT).

Cladonia furcata (HUDS.) SCHRAD. var. **paradoxa** WAINIO.
Cladonia cristatella TUCK.

*Fink, B. Bot. Gaz. 35: 195–208. Mr. 1903.

Cladonia gracilis (L.) WILLD. (forms of).
Cladonia verticillata HOFFM.
Cladonia coccifera (L.) WILLD.
Cladonia pyxidata (L.) FR. var.?
Cladonia fimbriata (L.) FR. (forms of).
Cladonia rangiferina (L.) WEB.
Cladonia uncialis (L.) WEB.
Cladonia alpestris (L.) RABENH.
Cladonia turgida (EHRH.) HOFFM.
Peltigera malacea (ACH.) FR.
Peltigera canina (L.) HOFFM.
Peltigera aphthosa (L.) HOFFM.

Professor Conway MacMillan finds such *Cladonia* formations especially well developed at Stair Portage and other points along the international boundary, and the writer has found them in many places in northern Minnesota. Next we will consider the *Umbilicaria* formations noted in many places along or near the international boundary from Grand Portage westward to Oak island in Lake of the Woods. And it should be stated that Professor MacMillan has noticed some of these *Umbilicaria* and *Cladonia* associations as well as those of the *Endocarpons* to follow below.*

UMBILICARIA FORMATION OF SHORE ROCKS (KETTLE FALLS).

Umbilicaria muhlenbergii (ACH.) TUCK.
Umbilicaria dillenii TUCK.
Umbilicaria vellea (L.) NYL.
Umbilicaria pustulata (L.) HOFFM.
Umbilicaria hyperborea HOFFM.

The formation recorded above may all be seen on a small area of partly flat and partly perpendicular and more shaded rocks along the shore of Rainy Lake at Kettle falls, and may be found almost as well developed near Rainy Lake City and in places on Oak and neighboring islands in Lake of the Woods. The formations were noted also at Koochiching and Tower and more poorly developed elsewhere. They are also finely developed in the region traversed in 1897 along the shores of Lake Superior and along the northern boundary from Grand Portage westward to Ely. At Grand Portage the formations

* MacMillan, C. Observations on the distribution of plants along the shore at Lake of the Woods. Minn. Bot. Stud. 1 : 1004–1020. 1897.

are well developed and were studied again during the summer of 1902. Here, on the upper slopes of Mount Josephine, may be observed almost pure formations of *Umbilicaria muhlenbergii* (Ach.) Tuck. and higher up this mixed with the last two species of the above list. Again, passing down to the more perpendicular and shaded rocks, the second and third species come in more and more, till in favorable spots we may find the two mixed in the same formation or limited pure formations of one, usually the second of the list. But even *Umbilicaria muhlenbergii* (Ach.) Tuck. does not shun shaded habitats when not occupied by other plants, and specimens exceeding one foot may be found on the shaded talus of Hat point at Grand Portage. And it must be taken into account that this is not one of the large species of the genus. On the surface of one of the large talus blocks of the point, figured in the Botanical Gazette,* Mr. C. J. Hibbard and the writer observed at the shore of Lake Superior one of these *Umbilicaria* societies in miniature with all of the species of the above list growing on the area of the rock about two feet square. Since these societies have not been previously studied in this series of papers, it has seemed best to pass somewhat beyond the proper confines of the present paper. The *Umbilicarias* like high rocks, but will descend nearly to the water level along the shores where they thrive best in Minnesota. No doubt the adaptation lies in the fact that these rock lichens, with unusually large thalli for lithophytic species, seek the moisture of the lake winds. Also, the species being in general arctic, subarctic or alpine forms, there is a temperature relation as well, and the cooling effect of the winds of the larger lakes influences their distribution materially. As is well known, the *Umbilicarias* are attached to the rocks in an unusually secure manner by a strong umbilicus. This protects them from destruction by being blown away on the high and frequently exposed rocks, though larger and less closely adnate to the substratum than most exposed rock lichens. Again, the thalli are strengthened by an unusually strong cortex, which holds them firmly against the rocks when dry and more easily broken. It is also noteworthy that the lower cortex is usually thicker than the upper and serves to hold against the upward tendency of strong winds, as well as for support of the large centrally attached thallus. It should be noted further that all of the spe-

* Fink, B. Bot. Gaz. l. c., Fig. 3.

cies of the genus known in Minnesota are included in the list above and may all be found in several portions of the state in an area of a few square rods or even a few feet.

Finally, another formation not previously presented, may be taken up, designating it as follows:

AMPHIBIOUS ANGIOCARPIC LICHEN FORMATION OF WET ROCKS (TOWER).

Endocarpon fluviatile DC.

Endocarpon miniatum (L.) SCHAER. var. **complicatum** SCHAER.

Staurothele umbrina (WAHL.) TUCK. var. **clopima** (WHLNB.) NYL.

Verrucaria viridula ACH.

This formation may be seen complete in places along the shore of Vermillion lake and less well represented at other portions of the lake shore. The same formation was observed in its entirety at Harding and all but the last member at Rainy Lake City. In a less close analysis this might of course be considered as a zone of a general lichen, or even general shore plant society, extending backward some distance from the shore line. The plants of the formation are quite different as to external appearance, and just what the adaptation is cannot be definitely stated. However, the three genera are closely related phylogenetically as may be seen in apothecial and spore structure as well as a general similarity as to algal symbionts. As to the latter, the last word has not been said, and some yet unknown difference in the algal members of these lichen-partnerships may account for the fact that some members of the genera of the above list are especially fond of wet rocks frequently inundated. Or it is possible that the plants have been recently forced to the water's edge by competing rivals and have become accustomed to the habitat without yet developing any noticeable structural adaptations.

Thus have been passed in order some fifteen or sixteen distinct classes of lichen formations, giving adaptations not previously stated in the earlier papers of this series as fully as seemed consistent with the general purposes of this survey, stating relationships between the formations especially presented and others of the region covered by this paper or the earlier papers, and thus attempting to make the present paper not only present the dominant features of ecologic distribution of lichens

in the area covered herein, but also to supplement as far as possible the work previously done. That a considerable amount of preliminary work could yet be profitably done both on the distribution and taxonomy of Minnesota lichens is apparent enough, and indeed the subject could hardly be completely exhausted. Yet, if nothing more is accomplished in a preliminary way, it is at least to be hoped that the results now scattered throughout several papers may be further correlated, somewhat amplified and brought together into more accessible form in a final report.

LIST OF SPECIES AND VARIETIES.

1. **Ramalina calicaris** (L.) Fr. var. **fraxinea** Fr.

On trees, rare. Warroad, July 1, 1901, no. 292. Oak island, July 10, 1901, no. 484. Emo, July 17, 1901, no. 644. Koochiching, July 27, 1901, no. 942 and July 26, 1901, no. 895. Kettle falls, August 13, 1901, no. 1426.

2. **Ramalina calicaris** (L.) Fr. var. **fastigiata** Fr.

On trees, common. Beaudette, June 18, 1901, no. 22 and June 22, 1901, no. 98. Warroad, June 25, 1901, nos. 165 and 169. Oak island, July 9, 1901, no. 438. Emo, July, no. 671 and July 18, 1901, no. 718. Koochiching, July 2, 1901, nos. 876 and 879. Rainy Lake City, August 3, 1901, nos. 1159 and 1172 and August 6, 1901, no. 1240. Kettle falls, August 13, 1901, no. 1415 and August 15, 1901, no. 1487. Harding, August 16, 1901, no. 1514. Tower, August 29, 1901, no. 1875.

Some specimens varying toward var. *canaliculata* Fr.

3. **Ramalina calicaris** (L.) var. **farinacea** Schaer.

Frequent on rocks and more rarely on trees. Beaudette, June 19, 1901, no. 47. Blueberry island, July 13, 1901, no. 508. Mainland, July 16, 1901, no. 635. Emo, July 19, 1901, no. 735 and July 22, 1901, no. 820. Koochiching, July 30, 1901, no. 1018. Rainy Lake City, August 1, 1901, no. 1100 and August 5, 1901, no. 1179. Kettle falls, August 10, 1901, no. 1375 and August 13, 1901, no. 1448. Harding, August 16, 1901, no. 1524, August 19, 1901, no. 1586 and August 21, 1901, no. 1666.

4. **Ramalina pusilla** (Prev.) Tuck.

On trees, rare except on balsams. Beaudette, June 24, 1901, no. 139. Oak island, July 8, 1901, no. 385. Emo, July, 1901, no. 657. Koochiching, July 29, 1901, no. 988.

5. **Ramalina pusilla** (PREV.) TUCK. var. **geniculata** TUCK.
With the last. Warroad, July 2, 1901, no. 325. Koochiching, July 27, 1901, no. 967. Rainy Lake City, August 3, 1901, no. 1149.

6. **Ramalina polymorpha** (ACH.) TUCK.
On rocks, rare. Rainy Lake City, August 5, 1901, no. 1203.

7. **Cetraria aurescens** TUCK.
On cedars in swamps, rare. Beaudette, June 20, 1901, no. 75. Warroad, June 29, 1901, no. 29. Mainland, July 16, 1901, no. 637. Koochiching, July 31, 1901, no. 1034. Kettle falls, August 13, 1901, no. 1423. Harding, August 16, 1901, nos. 1781 and 1798.

8. **Cetraria ciliaris** (ACH.) TUCK.
On trees, common, especially in swamps. Beaudette, June 18, 1901, nos. 23 and 30. Warroad, June 24, 1901, no. 270. Oak island, July 8, 1901, no. 392. Koochiching, July 27, 1901, no. 944. Rainy Lake City, August 5, 1901, no. 1179a. Kettle falls, August 9, 1901, no. 1334. Harding, August 19, 1901, no. 1569. Tower, August 27, 1901, no. 1834.

9. **Cetraria lacunosa** ACH.
On cedars in swamps, frequent. Beaudette, June 18, 1901, no. 26. Warroad, July 5, 1901, no. 376. Emo, July 19, 1901, no. 739. Koochiching, July 29, 1901, no. 993. Kettle falls, August 13, 1901, no. 1459. Harding, August 16, 1901, no. 1517. Tower, August 26, 1901, no. 1772.

10. **Cetraria juniperina** (L.) ACH. var. **pinastri** ACH.
On trees, rare and wandering to rocks near by. Beaudette, June 19, 1901, no. 35. Warroad, June 28, 1901, no. 240 and July 4, 1901, no. 357. Oak island, July 10, 1901, no. 505. Flag island, July 12, 1901, no. 546. Emo, July 25, 1901, no. 845. Koochiching, July 27, 1901, no. 960. Rainy Lake City, August 2, 1901, no. 1111. Kettle falls, August 9, 1901, no. 1349. Harding, August 19, 1901, no. 1571. Tower, August 23, 1901, no. 1689.

11. **Evernia prunastri** (L.) ACH.
On trees, common on cedars and tamaracks in swamps and wandering to rocks. Beaudette, June 18, 1901, no. 6. Warroad, June 27, 1901, no. 250. Oak island, July 9, 1901, no. 458 and July 10, 1901, no. 486. Emo, July 17, 1901, no. 641 and July 22, 1901, no. 822. Koochiching, July 26, 1901, no.

894 and July 31, 1901, no. 1046. Rainy Lake City, August 3, 1901, no. 1165. Kettle falls, August 13, 1901, nos. 1358 and 1403. Harding, August 19, 1901, no. 1573. Tower, August 23, 1901, no. 1692.

12. **Usnea barbata** (L.) FR. var. **florida** FR.

On trees, and infrequent, rarely wandering. Beaudette, June 18, 1901, no. 20. Warroad, June 26, 1901, no. 185. June 27, 1901, no. 207, June 28, 1901, no. 248, July 1, 1901, no. 297 and July 2, 1901, no. 332. Oak island, July 9, 1901, nos. 459 and 475. Emo, July 17, 1901, nos. 658 and 666 and July 22, 1901, no. 821. Koochiching, July 27, 1901, no. 938 and July 31, 1901, nos. 1023 and 1045. Rainy Lake City, August 2, 1901, no. 1116. Kettle falls, August 12, 1901, no. 1401 and August 13, 1901, nos. 1413 and 1429. Harding, August 16, 1901, no. 1519. Tower, August 23, 1901, no. 1676 and August 26, 1901, no. 1807.

13. **Usnea barbata** (L.) FR. var. **hirta** FR.

On trees, rare. Warroad, June 28, 1901, no. 245. Emo, July 18, 1901, no. 716. Koochiching, July 25, 1901, no. 875. Kettle falls, August 13, 1901, no. 1439 and August 14, 1901, no. 1469. Tower, August 26, 1901, no. 1790.

14. **Usnea barbata** (L.) FR. var. **ceratina** SCHAER.

On trees, frequent, especially on cedars in swamps. Beaudette, June 18, 1901, no. 33. Emo, July 18, 1901, no. 715. Rainy Lake City, August 3, 1901, no. 1176. Harding, August 16, 1901, no. 1512 and August 20, 1901, no. 1637. Tower, August 26, 1901, no. 1777.

15. **Usnea barbata** (L.) FR. var. **articulata** ACH.

On trees, rare. Beaudette, June 24, 1901, no. 143. Emo, July 18, 1901, no. 711. Harding, August 20, 1901, no. 1636.

Not previously reported from Minnesota.

16. **Usnea longissima** ACH.

On cedars in swamps, locally common. Kettle falls, August 15, 1901, no. 1584.

17. **Usnea cavernosa** TUCK.

On trees, usually cedars in swamps, frequent. Beaudette, June 18, 1901, no. 4. Warroad, July 2, 1901, no. 322. Oak island, July 9; 1901, no. 437. Emo, July 17, 1901, no. 677. Koochiching, July 25, 1901, no. 874 and July 31, 1901, no. 1032. Kettle falls, August 13, 1901, no. 1354. Harding,

August 16, 1901, no. 1503. Tower, August 26, 1901, nos. 1795 and 1806.

18. **Alectoria jubata** (L.) Tuck.

On trees, especially cedars and tamaracks, in swamps, rare. Warroad, July 5, 1901, no. 381. Emo, July 19, 1901, no. 726. Rainy Lake City, August 7, 1901, no. 1259. Kettle falls, August 13, 1901, nos. 1357 and 1449. Harding, August 20, 1901, no. 1631. Tower, August 26, 1901, no. 1778.

19. **Alectoria jubata** (L.) Tuck. var. **chalybeiformis** Ach.

On trees and old wood, frequent. Beaudette, June 19, 1901, no. 39. Warroad, June 28, 1901, no. 247. Oak island, July 8, 1901, no. 393. Koochiching, July 27, 1901, no. 951 and July 29, 1901, no. 978. Rainy Lake City, August 8, 1901, no. 1309. Kettle falls, August 9, 1901, no. 1331 and August 13, 1901, no. 1418. Harding, August 20, 1901, no. 1655 and August 21, 1901, no. 1668. Tower, August 24, 1901, no. 1741.

20. **Theloschistes chrysopthalmus** (L.) Norm.

On trees, rare. Le Clair, July 6, 1901, no. 381. Oak island, July 10, 1901, no. 485, and July 11, 1901, no. 520. Tower, August 28, 1901, no. 1865.

21. **Theloschistes polycarpus** (Ehrh.) Tuck.

On trees, common. Beaudette, June 18, 1901, no. 10. Warroad, June 25, 1901, no. 153. Oak island, July 10, 1901, no. 488. Emo, July 18, 1901, no. 701. Koochiching, July 25, 1901, no. 887 and July 31, 1901, no. 1051. Kettle falls, August 14, 1901, no. 1467. Harding, August 17, 1901, no. 1568. Tower, August 23, 1901, no. 1707.

22. **Theloschistes lychneus** (Nyl.) Tuck.

On trees and rocks, infrequent. Beaudette, June 21, 1901, no. 87. Warroad, June 26, 1901, no. 181. Oak island, July 10, 1901, no. 502 and 516. Emo, July 20, 1901, no. 782. Rainy Lake City, August 8, 1901, no. 1190. Harding, August 19, 1901, no. 1826.

23. **Theloschistes concolor** (Dicks.) Tuck. var. **effusa** Tuck.

On trees, rare. Rainy Lake City, August 7, 1901, no. 1260. Kettle falls, August 14, 1901, no. 1474. Harding, August 20, 1901, no. 1619.

24. **Parmelia perlata** (L.) Ach.

On rocks and trees, infrequent. Koochiching, July 29, 1901, no. 990. Rainy Lake City, August 5, 1901, no. 1214. Ket-

tle falls, August 10, 1901, no. 1366. Harding, August 19, 1901, nos. 1583 and 1612.

25. **Parmelia perlata** (L.) ACH. var. **ciliata** (DC.) NYL.

On mossy shaded rocks, rare. Rainy Lake City, August 5, 1901, no. 1223.

Very similar to plants referred to *P. perforata* (Jacq.) Ach. and *P. crinita* Ach. from the Superior region.

Not previously reported from Minnesota.

26. **Parmelia tiliacea** (HOFFM.) FLK.

On trees, common. Beaudette, June 18, 1901, no. 9. Warroad, June 25, 1901, no. 152. Emo, July 18, 1901, no. 693. Koochiching, July 26, 1901, no. 922. Rainy Lake City, August 2, 1901, no. 1125. Kettle falls, August 13, 1901, no. 1417. Harding, August 17, 1901, no. 1560. Tower, August 23, 1901, no. 1698.

27. **Parmelia borreri** TURN.

On trees and rocks, rare. Beaudette, June 22, 1901, no. 114. Oak island, July 10, 1901, no. 517. Emo, July 20, 1901. no. 777. Kettle falls, August 15, 1901, no. 1496.

28. **Parmelia borreri** TURN. var. **rudecta** TUCK.

On rocks and trees, especially common on cedars in swamps. Beaudette, June 22, 1901, no. 111. Warroad, June 24, 1901, 267. Koochiching, July 29, 1901, no. 989. Rainy Lake City, August 3, 1901, no. 1136. Kettle falls, August, 12, 1901, no. 1395. Tower, August 26, 1901, no. 1788.

29. **Parmelia saxatilis** (L.) FR.

On trees and rocks, common especially on cedars in swamps. Beaudette, June 18, 1901, no. 29, June 22, 1901, no. 112 and June 24, 1901, no. 129. Warroad, June 25, 1901, no. 166 and July 4, 1901, no. 355. Oak island, July 9, 1901, no. 435. Emo, July 19, 1901, no. 723 and July 20, 1901, no. 768. Koochiching, July 29, 1901, no. 999. Harding, August 16, 1901, no. 1506. Tower, August 24, 1901, no. 1748 and August 27, 1901, no. 1842.

30. **Parmelia saxatilis** (L.) FR. var. **sulcata** NYL.

On trees, frequent. Beaudette, June 18, 1901, no. 14. Warroad, June 25, 1901, no. 170. Flag island, July 12, 1901, no. 536. Koochiching, July 25, 1901, nos. 886 and 896 and July 31, 1901, no. 1056. Rainy Lake City, August 1, 1901, no. 1082. Kettle falls, August 12, 1901, no. 1380. Tower, August 23, 1901, no. 1710.

31. **Parmelia saxatilis** (L.) FR. var. **panniformis** ACH.

On rocks, infrequent. Blueberry island, July 13, 1901, no. 567. Rainy Lake City, August 7, 1901, no. 1252. Kettle falls, August 9, 1901, no. 1332. Harding, August 19, 1901, no. 1597 and no. 1607.

32. **Parmelia physodes** (L.) ACH.

On trees and rocks, common on trees in swamps. Beaudette, June 18, 1901, no. 6 and no. 28. Warroad, June 28, 1901, no. 246. Koochiching, July 27, 1901, no. 965 and July 31, 1901, no. 1050. Rainy Lake City, August 1, 1901, no. 1099 and August 7, 1901, no. 1267. Kettle falls, August 9, 1901, no. 1351 and August 12, 1901, no. 1402. Harding, August 17, 1901, no. 1553. Tower, August 24, 1901, no. 1720.

33. **Parmelia olivacea** (L.) ACH.

On trees, common. Beaudette, June 19, 1901, no. 56. Warroad, June 25, 1901, no. 147. Oak island, July 9, 1901, no. 464 and July 10, 1901, no. 492. Emo, July 18, 1901, no. 684. Koochiching, July 25, 1901, no. 889. Rainy Lake City, August 3, 1901, no. 1167. Harding, August 20, 1901, no. 1623. Tower, August 23, 1901, no. 1688.

34. **Parmelia olivacea** (L.) ACH. var. **prolixa** ACH.

On rocks, infrequent. Blueberry island, July 13, 1901, nos. 575 and 588. Rainy Lake City, August 8, 1901, nos. 1206 and 1281. Kettle falls, August 9, 1901, no. 1337. Tower, August 28, 1901, no. 1859.

35. **Parmelia conspurcata** (SCHAER.) WAINIO.

Frequent on trees and rarely on rocks. Beaudette, June 21, 1901, nos. 92 and 95. Warroad, June 25, 1901, no. 162 and June 26, 1901, no. 183. Oak island, July 11, 1901, no. 519. Emo, July 17, 1901, no. 667. Koochiching, July 31, 1901, no. 1029. Rainy Lake City, August 30, 1901, no. 1162. Tower, August 24, 1901, no. 1735.

36. **Parmelia caperata** (L.) ACH.

On trees and rocks, frequent, more common on trees in swamps. Beaudette, June 18, 1901, no. 18 and June 19, 1901, no. 50. Warroad, June 26, 1901, no. 182, June 28, 1901, no. 239 and July 4, 1901, no. 356. Oak island, July 11, 1901, no. 524. Emo, July 17, 1901, no. 646 and July 20, 1901, no. 769. Koochiching, July 27, 1901, no. 943 and July 31, 1901, no. 1059. Harding, August 16, 1901, no. 1510. Tower, August 24, 1901, no. 1718.

37. **Parmelia conspersa** (EHRH.) ACH.

On rocks, abundant. Warroad, July 4, 1901, no. 368. Emo, July 22, 1901, no. 814. Koochiching, July 31, 1901, no. 1041. Rainy Lake City, August 1, 1901, no. 1062. Kettle falls, August 9, 1901, no. 1330. Harding, August 19, 1901, no. 1601. Tower, August 24, 1901, no. 1743.

38. **Physcia speciosa** (WULF., ACH.) NYL.

On trees and rocks, frequent. Beaudette, June 19, 1901, no. 45, June 21, 1901, no. 93, and June 22, 1901, no. 117. Warroad, June 26, 1901, no. 180 and July 1, 1901, no. 300. Oak island, July 8, 1901, no. 398 and July 9, 1901, no. 441. Emo, July 17, 1901, no. 644. Rainy Lake City, August 1, 1901, no. 793. Koochiching, July 29, 1901, nos. 969 and 973 and July 31, 1901, no. 1058. Kettle falls, August 13, 1901, no. 1437. Harding, August 16, 1901, no. 1505 and August 17, 1901, no. 1558. Tower, August 23, 1901, no. 1691 and August 26, 1901, no. 1814.

39. **Physcia aquila** (ACH.) NYL.

On trees, rare. Harding, August 20, 1901, no. 1620. Tower, August 26, 1901, no. 1771 and 1784.

40. **Physcia aquila** (ACH.) NYL. var. **detonsa** TUCK.

On cedars, rare. Emo, July 23, 1901, no. 837. Koochiching, July 31, 1901, no. 1024.

41. **Physcia pulverulenta** (SCHREB.) NYL.

On trees, frequent. Beaudette, June 18, 1901, no. 13 and June 24, 1901, no. 140. Warroad, June 25, 1901, no. 163. Oak island, July 8, 1901, no. 407 and July 10, 1901, no. 486. Emo, July 17, 1901, nos. 639 and 664, July 18, 1901, no. 706 and July 22, 1901, no. 813. Koochiching, July 29, 1901, no. 982. Rainy Lake City, August 2, 1901, no. 1103 and August 5, 1901, no. 1210. Kettle falls, August 15, 1901, no. 1494. Harding, August 20, 1901, no. 1652. Tower, August 23, 1901, no. 1686.

42. **Physcia pulverulenta** (SCHREB.) NYL. var. **leucoleiptes** TUCK.

On trees and rocks, rare. Emo, July 23, 1901, no. 830. Rainy Lake City, August 5, 1901, no. 1196.

43. **Physcia stellaris** (L.) TUCK.

On trees and rocks, common. Beaudette, June 18, 1901, no. 7. Warroad, June 25, 1901, no. 148 and July 4, 1901, no.

363. Emo, July 18, 1901, no. 697. Oak island, July 10, 1901, nos. 489 and 495. Koochiching, July 26, 1901, no. 925 and July 31, 1901, no. 1052. Rainy Lake City, August 5, 1901, no. 1184. Kettle falls, August 9, 1901, no. 1326 and August 15, 1901, no. 1483. Harding, August 19, 1901, no. 1595. Tower, August 23, 1901, nos. 1695 and 1704.

44. **Physcia stellaris** (L.) TUCK. var. **apiola** NYL.

On rocks, rare. Oak island, July 9, 1901, no. 451. Rainy Lake City, August 15, 1901, no. 1098.

45. **Physcia astroidea** (FR.) NYL.

On rocks, infrequent. Oak island, July 8, 1901, no. 388 and July 10, 1901, nos. 501 and 510. Emo, July 22, 1901, no. 795. Koochiching, July 26, 1901, no. 906 and July 31, 1901, no. 1042. Tower, August 27, 1901, no. 1818.

46. **Physcia tribacia** (ACH.) TUCK.

On trees and rocks, infrequent. Le Clair, July 6, 1901, no. 382. Blueberry island, July 13, 1901, nos. 577 and 580. Emo, July 22, 1901, nos. 796 and 797. Koochiching, July 25, 1901, no. 885 and July 31, 1901, no. 1044. Harding, August 17, 1901, no. 1555. Tower, August 23, 1901, nos. 1685 and 1705 and August 27, 1901, no. 1816.

47. **Physcia hispida** (SCHREB., FR.) TUCK.

On trees and rocks, infrequent. Beaudette, June 19, 1901, no. 36. Warroad, June 25, 1901, no. 172. Le Clair, July 6, 1901, no. 384. Oak island, July 10, 1901, no. 497. Emo, July 18, 1901, no. 717. Koochiching, July 25, 1901, no. 860 and July 31, 1901, no. 1047. Rainy Lake City, August 1, 1901, no. 1077 and August 7, 1901, no. 1249. Tower, August 24, 1901, no. 1725.

48. **Physcia cæsia** (HOFFM.) NYL.

On rocks, infrequent. Koochiching, July 31, 1901, no. 1048. Rainy Lake City, August 1, 1901, no. 1070, August 1, 1901, no. 1262 and August 8, 1901, no. 1297. Harding, August 20, 1901, no. 1618.

49. **Physcia obscura** (EHRH.) NYL.

On trees and rocks, frequent. Beaudette, June 18, 1901, no. 8 and June 24, 1901, no. 136. Warroad, June 25, 1901, no. 156 and July 4, 1901, no. 364. Oak island, July 9, 1901, no. 450. Emo, July 19, 1901, no. 727 and July 20, 1901, nos. 793, and 803. Koochiching, July 26, 1901, no. 924 and July 31,

1901, no. 1053. Kettle falls, August 14, 1901, no. 1476. Harding, August 19, 1901, no. 1587.

50. **Physcia obscura** (Ehrh.) Nyl. var. **endochrysea** Nyl.

On rocks, rare. Rainy Lake City, August 2, 1901, no. 1127 and August 3, 1901, no. 1148. Harding, August 19, 1901, no. 1585 and 1611. Tower, August 23, 1901, no. 1683.

51. **Pyxine sorediata** Fr.

On cedars in swamps, rare. Emo, July 17, 1901, no. 652. Koochiching, July 29, 1901, no. 991. Rainy Lake City, August 7, 1901, no. 1250. Harding, August 20, 1901, no. 1653.

52. **Umbilicaria hyperborea** Hoffm. ?

On rocks, common in western portion of the region. Warroad, July 4, 1901, no. 345. Oak island, July 9, 1901, no. 477. Flag island, July 12, 1901, nos. 541 and 559. Blueberry island, July 13, 1901, no. 587. Emo, July 22, 1901, no. 801. Rainy Lake City, August 5, 1901, no. 1206. August 7, 1901, no. 1253 and August 8, 1901, no. 1298. Kettle falls, August 9, 1901, no. 1350 and August 15, 1901, no. 1495. Harding, August 21, 1901, no. 1658.

Part of the material seems much like *Umbilicaria flocculosa* Hoffm.

53. **Umbilicaria muhlenbergii** (Ach.) Tuck.

On rocks, frequent. Warroad, July 4, 1901, no. 346. Emo, July 20, 1901, no. 767. Koochiching, July 27, 1901, no. 939. Rainy Lake City, August 5, 1901, no. 1218. Kettle falls, August 12, 1901, no. 1398. Harding, August 17, 1901, no. 1538. Tower, August 24, 1901, no. 1727.

54. **Umbilicaria vellea** (L.) Nyl.

On rocks, rare. Oak island, July 9, 1901, no. 478. Blueberry island, July 13, 1901, no. 595. Rainy Lake City, August 7, 1901, no. 1268. Kettle falls, August 12, 1901, no. 1591. Tower, August 29, 1901, no. 1880.

55. **Umbilicaria dillenii** Tuck.

On rocks, infrequent. Blueberry island, July 13, 1901, no. 569. Rainy Lake City, August 3, 1901, no. 1134. Kettle falls, August 12, 1901, no. 1397. Harding, August 17, 1901, nos. 1536 and 1537. Tower, August 29, 1901, no. 1879.

56. **Umbilicaria pustulata** (L.) Hoffm.

On rocks, rare. Blueberry island, June 13, 1901, no. 571. Rainy Lake City, August 3, 1901, no. 1335. Kettle falls,

August 12, 1901, no. 1387. Harding, August 19, 1901, no. 1580.

57. **Sticta amplissima** (Scop.) Mass.

On cedars in swamps, infrequent. Emo, July 19, 1901, no. 759 and July 23, 1901, no. 848. Koochiching, July, 31, 1901, no. 1038. Kettle falls, August 13, 1901, no. 1452. Harding, August 20, 1901, no. 1624.

58. **Sticta pulmonaria** (L.) Ach.

On cedars in swamps, frequent. Beaudette, June 18, 1901, no. 5. Warroad, June 29, 1901, no. 275. Oak island, July 8, 1901, no. 421. Emo, July 17, 1901, nos. 642 and 648. Koochiching, July 27, 1901, no. 933 and July 30, 1901, no. 1005. Rainy Lake City, August 5, 1901, no. 1215. Kettle falls, August 13, 1901, no. 1453. Harding, August 17, 1901, no. 1546. Tower, August 26, 1901, no. 1794.

59. **Sticta quercizans** (Michx.) Ach.

On trees and rocks, rare. Emo, July 19, 1901, no. 744. Koochiching, July 31, 1901, no. 1037. Rainy Lake City, August 8, 1901, No. 1034.

Not previously reported from Minnesota.

60. **Sticta fuliginosa** (Dicks.) Ach.

On cedars in swamps, rare, and once on rocks. Emo, July 19, 1901, no. 743 and July 23, 1901, no. 846. Koochiching, July 29, 1901, no. 998. Kettle falls, August 10, 1901, nos. 1360 and 1362. Harding, August 17, 1901, no. 1550. Tower, August 26, 1901, no. 1774.

Not previously reported from Minnesota and new to the Mississippi valley.

61. **Sticta crocata** (L.) Ach.

On shaded rocks and trees, rare. Rainy Lake City, August 5, 1901, no. 1226. Kettle falls, August 10, 1901, nos. 1356, 1359 and 1378.

62. **Nephroma tomentosum** (Hoffm.) Kbr.

On rocks and trees, rare. Warroad, July 5, 1901, no. 382. Rainy Lake City, August 5, 1901, no. 1221. Kettle falls, August 10, 1901, nos. 1370 and 1410. Tower, August 24, 1901, no. 1747.

63. **Nephroma helveticum** Ach.

On rocks and trees, especially cedars, in swamps, frequent. Beaudette, June 21, 1901, no. 101. Warroad, July 1, 1901,

no. 299. Emo, July 17, 1901, no. 669 and July 19, 1901, no. 754. Koochiching, July 31, 1901, no. 1028. Rainy Lake City, August 1, 1901, no. 1074, August 2, 1901, no. 1123 and August 7, 1901, nos. 1205 and 1274. Kettle falls, August 9, 1901, no. 1336, August 13, 1901, no. 1361 and August 12, 1901, nos. 1383 and 1387. Harding, August 17, 1901, no. 1549. Tower, August 23, 1901, no. 1699 and August 26, 1901, no. 1800.

64. **Nephroma lævigatum** Ach.

On rocks at first locality and less frequent on cedars in swamps at the other three. Beaudette, June 20, 1901, no. 69. Oak island, July 8, 1901, no. 402. Koochiching, July 29, 1901, no. 1000. Rainy Lake City, August 3, 1901, no. 1138 and August 5, 1901, no. 1221.

65. **Nephroma lævigatum** Ach. var. **parile** Nyl.

On rocks, rare. Kettle falls, August 10, 1901, no. 1361.

66. **Peltigera aphthosa** (L.) Hoffm.

On earth, especially in cedar swamps, frequent. Beaudette, June 18, 1901, no. 17. Warroad, June 28, 1901, no. 226 and July 4, 1901, no. 356. Oak island, July 8, 1901, no. 424. Emo, July 19, 1901, no. 736 and July 23, 1901, no. 849. Koochiching, July 27, 1901, No. 947. Rainy Lake City, August 5, 1901, nos. 1213 and 1214. Kettle falls, August 10, 1901, no. 1356 and 1357 and August 12, 1901, no. 1390. Harding, August 17, 1901, no. 1544. Tower, August 27, 1901, no. 1835.

67. **Peltigera horizontalis** (L.) Hoffm.

On earth, usually in swamps, frequent. Beaudette, June 18, 1901, no. 1. Warroad, July 1, 1901, no. 313 and July 5, 1901, no. 373. Oak island, July 8, 1901, no. 425. Emo, July 19, 1901, no. 738. Koochiching, July 27, 1901, no. 929. Rainy Lake City, August 5, 1901, no. 1224. Kettle falls, August 10, 1901, no. 1377. Harding, August 19, 1901, no. 1584. Tower, August 28, 1901, no. 1853.

68. **Peltigera polydactyla** (Neck.) Hoffm.

On earth, in swamps, rare. Warroad, July 1, 1901, nos. 314 and 316. Koochiching, July 27, 1901, no. 956. Tower, August 27, 1901, no. 1832.

69. **Peltigera malacea** (Ach.) Fr.

On earth, over rocks, rare. Warroad, July 4, 1901, no. 336.

Blueberry island, July 15, 1901, no. 625. Emo, July 20, 1901, no. 765. Rainy Lake City, August 2, 1901, no. 1122. Kettle falls, August 10, 1901, no. 1363 and August 15, 1901, no. 1482. Tower, August 23, 1901, no. 1713.

Not previously reported from Minnesota and new to the Mississippi valley.

70. **Peltigera rufescens** (NECK.) HOFFM.

On earth, rare. Beaudette, June 18, 1901, no. 12. Warroad, June 27, 1901, no. 213. Oak island, July 8, 1901, no. 422. Emo, July 19, 1901, no. 752. Koochiching, July 27, 1901, no. 935. Kettle falls, August 10, 1901, no. 1373 and August 15, 1901, no. 1486.

71. **Peltigera canina** (L.) HOFFM.

On earth, common. Beaudette, June 18, 1901, no. 27, Warroad, June 27, 1901, no. 177. Oak island, July 9, 1901, no. 469. Emo, July 19, 1901, nos. 733, 748 and 750. Koochiching, July 27, 1901, no. 941. Rainy Lake City, August 3, 1901, no. 1128. Kettle falls, August 10, 1901, no. 1372. Harding, August 17, 1901, no. 1547 and August 21, 1901, no. 1665. Tower, August 26, 1901, no. 1844.

72. **Peltigera canina** (L.) HOFFM. var. **spongiosa** TUCK.

On earth in swamps, rare. Beaudette, June 18, 1901, no. 16. Oak island, July 8, 1901, no. 419. Koochiching, July 29, 1901, no. 994. Rainy Lake City, August 2, 1901, no. 1110. Harding, August 17, 1901, no. 1552. Tower, August 29, 1901, no. 1881.

73. **Peltigera canina** (L.) HOFFM. var. **spuria** ACH.

On earth, infrequent, Beaudette, June 24, 1901, nos. 132 and 141. Oak island, July 9, 1901, no. 447 and July 10, 1901, no. 509. Emo, July 19, 1901, no. 751. Koochiching, July 27, 1901, no. 946. Rainy Lake City, August 3, 1901, no. 1137. Harding, August 16, 1901, no. 1526. Tower, August 24, 1901, no. 1719.

74. **Peltigera canina** (L.) HOFFM. var. **sorediata** SCHAER.

On earth and rocks, infrequent. Warroad, June 26, 1901, no. 196. Emo, July 24, 1901, no. 855. Koochiching, July 25, 1901, no. 868. Rainy Lake City, August 1, 1901, no. 1082. Kettle falls, August 10, 1901, no. 1364.

75. **Peltigera canina** (L.) HOFFM. var. **leucorrhiza** FLK.

On earth in cedar swamps, rare. Oak island, July 8, 1901, no. 418. Mainland, July 16, 1901, no. 627.

76. **Pannaria languinosa** (Ach.) Kbr.

On mossy shaded rocks or trees' bases, frequent. Beaudette, June 18, 1901, no. 3 and June 20, 1901, no. 82. Warroad, June 26, 1901, no. 192. Flag island, July 12, 1901, no. 542. Emo, July 17, 1901, no. 638. Koochiching, July 25, 1901, no. 881. Rainy Lake City, August 3, 1901, no. 1169. Kettle falls, August 9, 1901, no. 1334. Harding, August 20, 1901, no. 1641.

77. **Pannaria rubiginosa** (Thunb.) Delis.

On cedars in swamps, rare. Oak island, July 8, 1901, no. 405. Emo, July 17, 1901, no. 654. Kettle falls, August 13, 1901, no. 1422.

Not previously reported from Minnesota.

78. **Pannaria rubiginosa** (Thunb.) Delis. var. **conoplea** Fr.

With the last and more frequent. Beaudette, June 24, 1901, no. 127. Emo, July 17, 1901, no. 637. Harding, August 17, 1901, no. 1565 and August 19, 1901, no. 1579. Tower, August 26, 1901, no. 1779.

Not previously reported from Minnesota and new to the upper Mississippi valley. This and the last above are very close to the plant called *P. lepidiota* Th. Fr. in the last report, and further study may result in bringing the two together. Also the two forms of *P. rubiginosa* (Thunb.) Delis seem to run to the next below, and that in turn is connected by intermediate forms with *P. microphylla* (Sw.) Delis, second below. Thus the three species as exhibited in Minnesota form a connected series.

79. **Pannaria leucosticta** Tuck.

On cedars in swamps, frequent, and more rarely on moss. Beaudette, June 24, 1901, no. 126. Warroad, July 5, 1901, no. 386. Blueberry island, July 13, 1901, no. 598. Emo, July 17, 1901, no. 656 and July 20, 1901, no. 781. Koochiching, July 29, 1901, no. 1003 and July 31, 1901, no. 1022. Rainy Lake City, August 5, 1901, no. 1207 and August 8, 1901, no. 1286. Kettle falls, August 13, 1901, no. 1355 and August 14, 1901, no. 1473. Harding, August 20, 1901, no. 1635. Tower, August 24, 1901, no. 1740 and August 27, 1901, no. 1837.

Not previously reported from Minnesota.

80. **Pannaria microphylla** (Sw.) Delis.

On rocks, locally common. Oak island, July 15, 1901, no. 618. Rainy Lake City, August 1, 1901, no. 1073 and August 3, 1901, no. 1170.

81. **Ephebe pubescens** Fr.

On flat rocks, rare. Harding, August 21, 1901, no. 1659.

82. **Ephebe solida** Born.

On rocks, locally frequent. Rainy Lake City, August 1, 1901, no. 794.

Both of the above were carefully examined and showed fungal hyphæ protruding from the filaments in clusters. The hyphæ in *E. solida* Born. were 3.5 to 6 mic. in diameter, much larger than those in the above species.

83. **Pyrenopsis** sp.

On rocks, rare and sterile. Blueberry island, July 13, 1901, no. 572. Probably one of the species previously found in Minnesota.

84. **Collema pycnocarpum** Nyl.

On trees, rare. Kettle falls, August 9, 1901, no. 1342 and August 13, 1901, no. 1416. Tower, August 26, 1901, no. 1771.

85. **Collema flaccidum** Ach.

Frequent on trees and more frequent on rocks. Beaudette, June 18, 1901, no. 2. Warroad, June 26, 1901, no. 190. Koochiching, July 25, 1901, no. 867 and July 27, 1901, no. 968. Rainy Lake City, August 8, 1901, no. 1280. Harding, August 19, 1901, no. 1606. Tower, August 27, 1901, no. 1829.

86. **Collema nigrescens** (Huds.) Ach.

On trees, frequent. Beaudette, June 18, 1901, no. 24. Warroad, June 26, 1901, no. 179. Oak island, July 8, 1901, no. 399. Emo, July 17, 1901, no. 650. Koochiching, July 31, 1901, no. 1031. Rainy Lake City, August 13, 1901, no. 1157. Kettle falls, August 9, 1901, no. 1340. Harding, August 16, 1901, no. 1511 and August 17, 1901, no. 1543. Tower, August 26, 1901, no. 1802.

87. **Collema nigrescens** (Huds.) Ach. var. **leucopepla** Tuck.

On trees, infrequent. Beaudette, June 20, 1901, no. 67. Warroad, June 26, 1901, no. 189. Emo, July 18, 1901, no. 710. Koochiching, July 29, 1901, no. 977. Kettle falls, August 9, 1901, no. 1323. Tower, August 26, 1901, no. 1815.

Shows the pruinose apothecia of the variety, but scarcely differs otherwise from the above. Not previously reported from Minnesota.

88. **Collema pulposum** (Bern.) Nyl.

On earth, common in last locality. Emo, July 24, 1901, no.

851. Koochiching, July 26, 1901, no. 925 and July 30, 1901, no. 1019.

89. **Collema limosum** ACH.

On shaded earth, rare. Koochiching, July 26, 1901, no. 918.

90. **Leptogium lacerum** (SW.) FR.

On earth and mossy rocks, rare. Beaudette, June 22, 1901, no. 119. Oak island, July 9, 1901, no. 440. Emo, July 24, 1901, no. 853. Koochiching, July 29, 1901, no. 970. Rainy Lake City, August 5, 1901, no. 1208. Kettle falls, August 13, 1901, no. 1412.

91. **Leptogium pulchellum** (ACH.) NYL.

On cedars in swamps, rare. Warroad, June 28, 1901, no. 254 and July 5, 1901, no. 387. Emo, July 23, 1901, no. 835. Koochiching, July 29, 1901, no. 997.

92. **Leptogium tremelloides** (L.) FR.

Frequent on rocks and less common on cedars in swamps. Beaudette, June 24, 1901, no. 145. Oak island, July 8, 1901, no. 430 and August 9, 1901, no. 433. Emo, July 17, 1901, no. 678 and July 17, 1901, no. 812. Koochiching, July 26, 1901, no. 904. Rainy Lake City, August 1, 1901, nos. 1071 and 1078 and August 8, 1901, no. 1246. Kettle falls, August 12, 1901, no. 1409. Harding, August 20, 1901, no. 1651. Tower, August 23, 1901, no. 1690.

93. **Leptogium myochroum** (EHRH., SCHAER.) TUCK.

Frequent on trees, especially in swamps, rare on rocks. Beaudette, June 19, 1901, no. 42, June 21, 1901, no. 196 and June 24, 1901, no. 144. Oak island, July 8, 1901, no. 412. Emo, July 17, 1901, no. 643. Koochiching, July 27, 1901, no. 934. Kettle falls, August 12, 1901, nos. 1360 and 1388. Tower, August 23, 1901, no. 1684.

94. **Leptogium myochroum** (EHRH., SCHAER.) TUCK. var. **tomentosum** SCHAER.

On trees, frequent. Warroad, June 27, 1901, no. 214 and July 1, 1901, no. 310. Rainy Lake City, August 3, 1901, no. 1153. Kettle falls, August 10, 1901, no. 1371. Harding, August 16, 1901, no. 1527.

95. **Placodium elegans** (LINK.) DC.

On rocks, infrequent. Flag island, July 12, 1901, no. 548. Emo, July 22, 1901, no. 807. Rainy Lake City, August 5, 1901, no. 1191 and August 6, 1901, no. 1238. Kettle falls,

August 15, 1901, no. 1585. Tower, August 28, 1901, no. 1849.

96. **Placodium murorum** (HOFFM.) DC.

On rocks, rare. Rainy Lake City, August 5, 1901, no. 1192.

97. **Placodium cinnabarium** (ACH.) ANZ.

On rocks, infrequent. Oak island, July 15, 1901, no. 617. Emo, July 22, 1901, no. 809. Koochiching, July 27, 1901, no. 963. Rainy Lake City, August 1, 1901, no. 1063. Tower, August 24, 1901, no. 1746.

98. **Placodium citrinum** (HOFFM.) LEIGHT.

On rocks, common and fruited at Harding, elsewhere rare and sterile. Rainy Lake City, August 7, 1901, no. 1244. Harding, August 20, 1901, no. 1616. Tower, August 23, 1901, no. 1711.

99. **Placodium aurantiacum** (LIGHT.) NAEG. and HEPP.

On rocks, infrequent. Le Clair, July 6, 1901, no. 380. Oak island, July 15, 1901, no. 624. Rainy Lake City, August 16, 1901, no. 1232. Kettle falls, August 14, 1901, no. 1478. Tower, August 27, 1901, no. 1843.

100. **Placodium cerinum** (HEDW.) NAEG. and HEPP.

On trees, common. Beaudette, June 21, 1901, no. 88. Warroad, June 25, 1901, no. 150, June 26, 1901, no. 184 and June 29, 1901, no. 279. Oak island, July 10, 1901, no. 512. Flag island, July 12, 1901, no. 551. Emo, July 18, 1901, no. 698. Koochiching, July 26, 1901, no. 893 and July 31, 1901, no. 1027. Rainy Lake City, August 8, 1901, no. 1299. Harding, August 19, 1901, no. 1581. Tower, August 23, 1901, no. 1692 and August 24, 1901, nos. 1731 and 1739.

101. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **sideritis** TUCK.

On rocks, infrequent. Emo, July 20, 1901, no. 787. Koochiching, July 26, 1901, no. 909, and July 31, 1901, no. 1043. Rainy Lake City, August 1, 1901, nos. 1064 and 1075. Tower, August 24, 1901, no. 1749 and August 28, 1901, no. 1848.

102. **Placodium cerinum** (HEDW.) NAEG. and HEPP. var. **pyracea** NYL.

On old wood, rare. Beaudette, June 20, 1901, no. 76. Koochiching, July 29, 1901, no. 976. Rainy Lake City, August 6, 1901, no. 1231. Harding, August 20, 1901, no. 1621.

103. **Placodium ferrugineum** (HUDS.) HEPP.

On dead cedars, rare. Rainy Lake City, August 5, 1901, nos. 1193 and 1199.

104. **Placodium ferrugineum** (HUDS.) HEPP. var. **pollinii** TUCK.

On dead cedars, rare. Rainy Lake City, August 5, 1901, no. 1188.

105. **Placodium vitellinum** (EHRH.) NAEG. and HEPP.

On rocks and old wood, infrequent. Oak island, July 8, 1901, no. 404 and July 10, 1901, no. 490. Emo, July 22, 1901, no. 811. Koochiching, July 27, 1901, no. 948. Rainy Lake City, August 1, 1901, no. 1067 and August 6, 1901, no. 1227.

106. **Placodium vitellinum** (EHRH.) NAEG. and HEPP. var. **aurellum** ACH.

On rocks, infrequent. Flag island, July 12, 1901, no. 544. Blueberry island, July 13, 1901, no. 564. Koochiching, July 31, 1901, no. 1049. Rainy Lake City, August 1, 1901, no. 1068. Tower, August 24, 1901, no. 1738.

107. **Lecanora rubina** (VILL.) ACH.

On rocks, rare or infrequent. July 10, 1901, no. 508. Blueberry island, July 13, 1901, nos. 590 and 599. Emo, July 22, 1901, no. 810. Koochiching, July 31, 1901, no. 1060. Rainy Lake City, August 2, 1901, nos. 1102 and 1104 and August 8, 1901, no. 1207. Tower, August 28, 1901, nos. 1851 and 1852.

108. **Lecanora rubina** (VILL.) ACH. var. **heteromorpha** ACH.

On rocks, infrequent. Blueberry island, July 13, 1901, no. 605. Rainy Lake City, July 8, 1901, no. 1277. Kettle falls, August 9, 1901, no. 1344. Tower, August 28, 1901, nos. 1850 and 1862.

109. **Lecanora muralis** (SCHREB.) SCHAER.

On rocks, locally frequent. Blueberry island, July 13, 1901, no. 591.

110. **Lecanora muralis** (SCHREB.) SCHAER. var. **saxicola** SCHAER.

On rocks, infrequent. Oak island, July 10, 1901, no. 518. Flag island, July 13, 1901, no. 543. Emo, July 22, 1901, no. 823. Koochiching, July 26, 1901, no. 927. Rainy Lake City, August 1, 1901, no. 1069. Harding, August 17, 1901, no. 1541.

111. **Lecanora muralis** (SCHREB.) SCHAER. var. **garovaglii** ANZ.

On rocks, locally common. Koochiching, July 31, 1901, no. 1039.

Not previously reported from Minnesota.

112. **Lecanora pallida** (SCHREB.) SCHAER.

On cedars and tamaracks in swamps, frequent at the second .ocality. Beaudette, June 19, 1901, no. 54. Warroad, June 28, 1901, nos. 228 and 232.

113. **Lecanora frustulosa** (DICKS.) MASS.

On rocks, infrequent. Oak island, July 11, 1901, no. 521. Blueberry island, July 13, 1901, no. 600. Oak island, July 15, 1901, no. 614. Rainy Lake City, August 1, 1901, no. 1087. Kettle falls, August 15, 1901, no. 1488.

Some of the smaller material suggests forms of *Lecanora subfusca* (L.) Ach.

114. **Lecanora subfusca** (L.) ACH.

On trees, common. Beaudette, June 18, 1901, no. 21 and June 20, 1901, no. 74. Warroad, June 26, 1901, no. 195 and July 5, 1901, no. 384. Emo, July 18, 1901, no. 687. Koochiching, July 25, 1901, no. 888. Rainy Lake City, August 5, 1901, no. 1180. Kettle falls, August 9, 1901, no. 1347. Harding, August 19, 1901, nos. 1589 and 1605 and August 20, 1901, no. 1628. Tower, August 28, 1901, no. 1680.

115. **Lecanora subfusca** (L.) ACH. var. **allophana** ACH.

On cedars in swamps, common. Beaudette, June 22, 1901, nos. 113 and 124. Warroad, July 1, 1901, no. 307. Emo, July 17, 1901, no. 649. Harding, August 19, 1901, no. 1572. Tower, August 26, 1901, nos. 1783 and 1797.

116. **Lecanora subfusca** (L.) ACH. var. **argentata** ACH.

On trees, rare. Beaudette, June 21, 1901, no. 109. Warroad, June 25, 1901, no. 155. Rainy Lake City, August 8, 1901, no. 1279.

117. **Lecanora subfusca** (L.) ACH. var. **coilocarpa** ACH.

On cedars in swamps, rare. Beaudette, June 19, 1901, no. 53. Warroad, July 1, 1901, no. 312.

118. **Lecanora variolascens** (FR.) NYL.

On trees, frequent. Beaudette, June 21, 1901, no. 108. Warroad, June 26, 1901, no. 174. Oak island, July 9, 1901, no. 452. Emo, July 19, 1901, no. 746. Koochiching, July 25, 1901, no. 861. Kettle falls, August 14, 1901, no. 1463.

119. **Lecanora hageni** ACH.

On rocks, rare. Rainy Lake City, August 5, 1901, no. 1200. A peculiar form.

120. **Lecanora varia** (EHRH.) NYL.

On rocks and trees, frequent. Oak island, July 10, 1901, no. 503 and July 11, 1901, no. 523. Flag island, July 12, 1901, no. 561. Blueberry island, July 13, 1901, no. 593. Emo, July 22, 1901, no. 819. Rainy Lake City, August 1, 1901, no. 1065, August 5, 1901, no. 1187, August 7, 1901, no. 1251 and August 8, 1901, no. 1280. Harding, August 21, 1901, nos. 1662 and 1663. Tower, August 24, 1901, nos. 1716 and 1737.

121. **Lecanora varia** (EHRH.) NYL. var. **symmicta** ACH.

On dead and living wood, frequent. Beaudette, June 20, 1901, no. 71. Warroad, June 26, 1901, no. 187. Blueberry island, July 13, 1901, no. 586. Emo, July 18, 1901, no. 696. Koochiching, July 25, 1901, no. 689, July 26, 1901, nos. 891 and 919, July 27, 1901, no. 949 and July 29, 1901, no. 979. Rainy Lake City, August 2, 1901, nos. 1124 and 1126 and August 6, 1901, no. 1228. Kettle falls, August 9, 1901, no. 1333. Harding, August 20, 1901, no. 1648. Tower, August 23, 1901, nos. 1672 and 1706 and August 26, 1901, nos. 1773 and 1787.

122. **Lecanora varia** (EHRH.) NYL. var. **polytropa** NYL.

On rocks, rare. Warroad, July 7, 1901, no. 367.

123. **Lecanora dispersa** PERS.

On old wood, rare. Warroad, June 29, 1901, no. 277. Le Clair, July 6, 1901, no. 383. Rainy Lake City, August 2, 1901, no. 1112.

Spores somewhat smaller than those of plants from Europe, and the plants also exhibiting better thalline exciple in ours. Also near *Lecanora effusa* (Pers.) Ach. collected in Nebraska by T. H. Williams.

Not previously reported from Minnesota and new to the interior of North America.

124. **Lecanora pallescens** (L.) SCHAER.

On cedars in swamps, frequent. Beaudette, June 19, 1901, nos. 60 and 62 and June 20, 1901, no. 70. Warroad, June 29, 1901, nos. 263 and 274 and July 1, 1901, nos. 293, 302, 308 and 309. Oak island, July 9, 1901, no. 434. Mainland, July

16, 1901, no. 628. Emo, July 17, 1901, no. 673 and July 23, 1901, no. 831. Koochiching, July 25, 1901, no. 880 and July 29, 1901, no. 1001. Rainy Lake City, August 3, 1901, no. 1160. Kettle falls, August 9, 1901, no. 1317 and August 13, 1901, no. 1451. Harding, August 16, 1901, no. 1507 and August 19, 1901, no. 1610. Tower, August 26, 1901, no. 1799.

125. **Lecanora verrucosa** (ACH.) LAUR. var. **mutabilis** TH. FR.

On trees, rare. Oak island, July 8, 1901, no. 406 and July 8, 1901, no. 466. Emo, July 18, 1901, no. 694. Harding, August 19, 1901, no. 1592.

126. **Lecanora subepulotica** NYL.

On rocks, rare. Emo, July 22, 1901, no. 816.

Not previously reported from Minnesota and new to the interior of North America.

127. **Lecanora cinerea** (L.) SOMMERF.

On rocks, common. Warroad, July 4, 1901, no. 371. Oak island, July 9, 1901, nos. 454 and 479, July 10, 1901, nos. 483 and 514, July 11, 1901, nos. 522 and 526 and July 15, 1901, nos. 619 and 621. Emo, July 20, 1901, nos. 788 and 791 and July 22, 1901, no. 815. Koochiching, July 26, 1901, no. 911. Kettle falls, August 9, 1901, no. 1346. Harding, August 19, 1901, no. 1603, and August 20, 1901, no. 1617. Tower, August 23, 1901, nos. 1669 and 1708. August 24, 1901, nos. 1728 and 1730 and August 28, 1901, no. 1860.

128. **Lecanora cinerea** (L.) SOMMERF. var. **lævata** FR.

On rocks, common. Warroad, July 4, 1901, nos. 366 and 370. Oak island, July 10, 1901, nos. 499 and 515. Blueberry island, July 13, 1901, nos. 562 and 563. Rainy Lake City, August 6, 1901, no. 1230. Harding, August 19, 1901, nos. 1601 and 1608.

129. **Lecanora cinerea** (L.) SOMMERF. var. **gibbosa** NYL.

On rocks, rare. Oak island, July 15, 1901, no. 620. Koochiching, July 26, 1901, no. 917.

130. **Lecanora calcarea** (L.) SOMMERF.?

On rocks, rare. Harding, August 21, 1901, no. 1664.

Scarcely differing from some forms referred to *L. cinerea* (L.) Sommerf., except in the plainly pruinose apothecia.

131. **Lecanora lacustris** (WITH.) NYL.

On wet rocks, rare. Harding, August 16, 1901, nos. 1518 and 1528.

Not previously reported from Minnesota and new to the interior of North America.

132. **Lecanora fuscata** (SCHRAD.) TH. FR.

Common on rocks and collected at Tower on old wood. Oak island, July 9, 1901, no. 480 and July 10, 1901, no. 482. Emo, July 20, 1901, no. 780. Koochiching, July 26, 1901, no. 923. Rainy Lake City, August 1, 1901, no. 1101. Harding, August 20, 1901, no. 1615. Tower, August 23, 1901, no. 1671, August 24, 1901, nos. 1721 and 1736 and August 27, 1901, no. 1840.

133. **Rinodina oreina** (ACH.) MASS.

On rocks, rare. Warroad, July 4, 1901, no. 358. Oak island, July 9, 1901, no. 474, and July 10, 1901, no. 513. Emo, July 22, 1901, no. 805. Koochiching, July 31, 1901, no. 1057. Rainy Lake City, August 1, 1901, no. 1088. Kettle falls, August 9, 1901, no. 1335. Tower, August 27, 1901, no. 1822.

134. **Rinodina sophodes** (ACH.) NYL.

On trees and rocks, common. Warroad, June 25, 1901, no. 160 and June 28, 1901, no. 237. Oak island, July 10, 1901, no. 500. Koochiching, July 27, 1901, no. 959. Rainy Lake City, August 6, 1901, no. 1243. Harding, August 21, 1901, no. 1660. Tower, August 23, 1901, nos. 1682 and 1700, August 24, 1901, no. 1729 and August 27, 1901, no. 1819.

135. **Rinodina sophodes** (ACH.) NYL. var. **exigua** FR.

On trees and old wood, rare. Warroad, June 23, 1901, no. 223. Koochiching, July 29, 1901, no. 972.

136. **Rinodina sophodes** (ACH.) NYL. var. **tephraspis** TUCK.

On rocks, rare. Warroad, July 4, 1901, no. 372. Flag island, July 12, 1901, no. 540. Tower, August 23, 1901, no. 1702 and August 24, 1901, no. 1759.

137. **Rinodina lecanorina** MASS.

On rocks, rare. Oak island, July 10, 1901, no. 511. Koochiching, July 20, 1901, no. 901. Rainy Lake City, August 1, 1901, nos. 1072 and 1081.

138. **Pertusaria velata** (TURN.) NYL.

Frequent on trees and rarely on rocks. Emo, July 17, 1901, no. 680 and July 22, 1901, no. 840. Rainy Lake City, August 1, 1901, no. 1091. Kettle falls, August 13, 1901, no.

1421. Harding, August 14, 1901, no. 1594 and August 20, 1901, no. 1622. Tower, August 26, 1901, no. 1793.

139. **Pertusaria multipuncta** (TURN.) NYL.

On cedars in swamps, frequent. Beaudette, June 22, 1901, no. 125. Warroad, June 29, 1901, nos. 257 and 280 and July 1, 1901, no. 288. Emo, July 23, 1901, no. 843. Koochiching, July 30, 1901, no. 1019.

140. **Pertusaria communis** DC.

On cedars in swamps, common. Beaudette, June 6, 1901, no. 64. Warroad, June 29, 1901, no. 282 and July 1, 1901, no. 304. Oak island, July 9, 1901, no. 448. Emo, July 18, 1901, no. 713. Koochiching, July 30, 1901, no. 1021. Rainy Lake City, August 8, 1901, no. 1282. Kettle falls, August 9, 1901, no. 1341 and August 13, 1901, no. 1441. Harding, August 19, 1901, no. 1577. Tower, August 26, 1901, nos. 1810 and 1805.

141. **Pertusaria pustulata** (ACH.) NYL.

On trees, rare. Kettle falls, August 13, 1901, no. 1438.

142. **Pertusaria leioplaca** (ACH.) SCHAER.

On trees, frequent. Beaudette, June 19, 1901, no. 65. Warroad, June 26, 1901, no. 173, and July 2, 1901, no. 324. Oak island, July 9, 1901, no. 455. Emo, July 18, 1901, no. 703. Koochiching, July 25, 1901, no. 882 and July 26, 1901, no. 899. Rainy Lake City, August 3, 1901, nos. 1166 and 1174, and August 5, 1901, no. 1182. Kettle falls, August 13, 1901, nos. 1420 and 1425. Tower, August 29, 1901, no. 1874.

143. **Pertusaria ophthalniza** NYL.?

On trees, probably common though seldom seen. Beaudette, June 24, 1901, no. 133. Mainland, July 16, 1901, no. 631. Tower, August 26, 1901, no. 1812.

Spores are only 100–155 by 24–45 mic., while published descriptions give 160–205 by 80–100 mic. as the size. However, Dr. Arnold so names a plant from Newfoundland having spores only 90–135 by 35–48 mic.

144. **Gyalecta lutea** (DICKS.) TUCK.

On an old *Polyporus*, rare. Emo, July 23, 1901, no. 828.

But the border of the exciple not radiate.

145. **Urceolaria scruposa** (L.) Nyl.

On rocks, infequent and rarely on cedars in swamps at second locality. Oak island, July 15, 1901, no. 615. Emo, July 17, 1901, nos. 651 and 662, July 20, 1901, no. 784 and July 23, 1901, no. 839. Rainy Lake City, August 2, 1901, no. 1109. Kettle falls, August 9, 1901, no. 1345. Harding, August 20, 1901, no. 1650. Tower, August 27, 1901, no. 1838.

146. **Stereocaulon paschale** (L.) Fr.

On rocks, frequent, or on earth over rocks. Warroad, July 4, 1901, no. 337. Emo, July 20, 1901, no. 766. Koochiching, July 25, 1901, no. 865. Kettle falls, August 12, 1901, no. 1385. Harding, August 20, 1901, no. 1629. Tower, August 23, 1901, no. 1679.

147. **Stereocaulon tomentosum** (Fr.) Th. Fr.

On rocks, locally common. Oak island, July 9, 1901, no. 471.

Not previously reported from Minnesota.

148. **Cladonia rangiferina** (L.) Web.

On earth, generally over rocks, common. Beaudette, June 19, 1901, no. 43. Warroad, June 28, 1901, nos. 233 and 236 and July 4, 1901, no. 349. Flag island, July 12, 1901, nos. 539 and 556. Emo, July 19, 1901, no. 734. Kettle falls, August 12, 1901, no. 1392. Harding, August 17, 1901, no. 1539. Tower, August 24, 1901, no. 1763.

149. **Cladonia sylvatica** (L.) Hoffm. var. **pumila** Ach.

On earth, usually over rocks, common. Warroad, June 26, 1901, no. 273. Oak island, July 10, 1901, no. 491. Kettle falls, August 12, 1901, no. 1405. Tower, August 23, 1901, no. 1701.

Not previously reported from Minnesota.

150. **Cladonia sylvatica** (L.) Hoffm. var. **sylvestris** Oed.

On rocky earth, rare. Warroad, June 27, 1901, no. 202. Blueberry island, July 13, 1901, no. 585. Tower, August 29, 1901, no. 1885.

Not previously reported from Minnesota.

151. **Cladonia alpestris** (L.) Rabenh.

On earth, usually over rocks, infrequent. Warroad, July 14, 1901, no. 340. Flag island, July 12, 1901, no. 552. Kettle

falls, August 13, 1901, no. 1414. Tower, August 29, 1901, no. 1872.

152. **Cladonia bacillaris** NYL.

On earth and old wood, rare. Kettle falls, August 10, 1901, no. 1365. Tower, August 24, 1901, no. 1723, and August 27, 1901, no. 1823.

153. **Cladonia macilenta** (HOFFM.) NYL.

On earth and old wood, common. Blueberry island, July 13, 1901, nos. 582 and 584. Harding, August 16, 1901, no. 1504 and August 17, 1901, no. 1561.

154. **Cladonia digitata** SCHAER.

On old logs in cedar swamps, rare. Warroad, July 2, 1901, no. 327. Harding, August 17, 1901, no. 1557.

155. **Cladonia coccifera** (L.) WILLD.

On earth over rocks, infrequent. Blueberry island, July 13, 1901, no. 578. Rainy Lake City, August 1, 1901, no. 1086.

Previously reported as *Cladonia cornucopiodes* (L.) Fr.

156. **Cladonia coccifera** (L.) WILLD. var. **stemmatina** ACH.

On earth over rocks, infrequent. Warroad, July 4, 1901, no. 343. Emo, July 22, 1901, no. 808. Rainy Lake City, August 2, 1901, no. 1147.

Not previously reported from Minnesota.

157. **Cladonia coccifera** (L.) WILLD. var. **pleurota** (FLK.) SCHAER.

On mossy rocks, infrequent. Rainy Lake City, August 1, 1901, no. 1089. Kettle falls, August 10, 1901, no. 1362.

Not previously reported from Minnesota.

158. **Cladonia deformis** HOFFM.

On earth, rare. Blueberry island, July 13, 1901, no. 592.

159. **Cladonia cristatella** TUCK.

On old wood and earth, frequent. Beaudette, June 19, 1901, no. 40. Warroad, June 27, 1901, no. 219; July 1, 1901, no. 294; July 2, 1901, 328 and July 4, 1901, no. 342. Oak island, July 8, 1901, no. 387 and July 9, 1901, no. 476. Flag island, July 12, 1901, no. 554. Emo, July 18, 1901, no. 695. Koochiching, July 25, 1901, no. 873, and July 27, 1901, no. 940 and 958. Rainy Lake City, August 1, 1901, no. 1090; August 2, 1901, no. 1115, and August 7, 1901, no. 1276. Kettle falls,

August 10, 1901, nos. 1368 and 1374. Harding, August 17, 1901, no. 1542. Tower, August 24, 1901, no. 1724.

160. **Cladonia cristatella** TUCK. var. **vestita** TUCK.

On rocks, locally common. Tower, August 2, 1901, no. 1754.

Not previously reported from Minnesota, and new to the Mississippi valley.

161. **Cladonia amaurocræa** (FLK.) SCHAER.

On earth over rocks, frequent. Warroad, July 4, 1901, no. 359. Blueberry island, July 17, 1901, nos. 576, 606 and 607. Emo, July 20, 1901, no. 775. Koochiching, July 27, 1901, no. 937. Rainy Lake City, August 3, 1901, no. 1129, and August 8, 1901, nos. 1310 and 1311. Kettle falls, August 12, 1901, no. 1379. Harding, August 17, 1901, no. 1564 and August 20, 1901, no. 1640. Tower, August 29, 1901, nos. 1866 and 1870.

162. **Cladonia uncialis** (L.) WEB.

On earth, usually over rocks, frequent. Warroad, July 4, 1901, no. 338. Flag island, July 12, 1901, no. 535. Emo, July 20, 1901, no. 773. Koochiching, July 31, 1901, no. 1036. Rainy Lake City, August 2, 1901, no. 1108, and August 5, 1901, no. 1220. Kettle falls, August 12, 1901, no. 1394. Tower, August 29, 1901, no. 1871.

163. **Cladonia uncialis** (L.) WEB. var. **obtusata** ACH.

On earth, rare. Blueberry island, July 13, 1901, no. 597.

Not previously reported from Minnesota and new to North America.

164. **Cladonia furcata** (HUDS.) SCHRAD.

On earth and old wood, rare. Emo, July 19, 1901, no. 728, and July 21, 1901, no. 771. Koochiching, July 30, 1901, no. 1009.

165. **Cladonia furcata** (HUDS.) var. **pinnata** (FLK.) WAINIO.

On earth over rocks, infrequent. Rain Lake City, August 7, no. 1273.

Not previously reported from Minnesota.

166. **Cladonia furcata** (HUDS.) SCHRAD. var. **scabriuscula** (DEL.) COEM.

On earth and old wood, frequent. Warroad, July 5, 1901, no. 374. Emo, July 20, 1901, no. 764. Koochiching, July

25, 1901, no. 900, and July 31, 1901, no. 1032. Rainy Lake City, August 3, 1901, no. 1177, August 5, 1901, no. 1216 and August 7, 1901, no. 1272. Kettle falls, August 10, 1901, 1386.

167. **Cladonia furcata** (HUDS.) SCHRAD. var. **paradoxa** WAINIO.

On old wood and earth, frequent. Beaudette, June 19, 1901, no. 44. Warroad, July 4, 1901, no. 352. Emo, July 20, 1901, no. 779. Koochiching, July 25, 1901, no. 863. Harding, August 20, 1901, no. 1654. Tower, August 23, 1901, no. 1694.

168. **Cladonia furcata** (HUDS.) SCHRAD. var. **finkii** WAINIO.

On earth and old wood, frequent. Beaudette, June 19, 1901, no. 46. Oak island, July 8, 1901, nos. 414 and 415, and July 9, 1901, no. 465. Flag island, July 12, 1901, no. 532. Oak island, July 15, 1901, no. 612. Emo, July 18, 1901, no. 688, July 19, 1901, no. 747 and July 20, 1901, no. 772. Koochiching, July 30, 1901, no. 1011. Rainy Lake City, August 8, 1901, nos. 1283 and 1295. Kettle falls, August 14, 1901, no. 1464. Harding, August 17, 1901, no. 1548. Tower, August 24, 1901, nos. 1726, 1745 and 1763, and August 27, 1901, no. 1828.

A new variety. Dr. Wainio's description is not at hand, but will appear later.

169. **Cladonia crispata** (ACH.) FLT.

On earth and old wood, infrequent. Warroad, June 29, 1901, no. 256 and July 4, 1901, no. 348. Tower, August 24, 1901, no. 1715.

Previously reported as *Cladonia furcata* (Huds.) Fr. var. *crispala* Flk.

170. **Cladonia crispata** (ACH.) FLT. var. **infundibulifera** (SCHAER.) WAINIO.

On earth and old logs, common. Emo, July 19, 1901, no. 731. Koochiching, July 29, 1901, no. 992. Kettle falls, August 12, 1901, no. 1393.

Not previously reported from Minnesota, and new to the Mississippi valley.

171. **Cladonia squamosa** (SCOP.) HOFFM.

On earth and old wood, frequent. Beaudette, June 24, 1901, no. 131. Emo, July 23, 1901, no. 836. Koochiching, July 29, 1901, no. 996 and August 30, 1901, no. 1010. Rainy Lake City, August 1, 1901, no. 1097, August 5, 1901, no. 1225 and

August 8, 1901, no. 1296, and 1300. Kettle falls, August 12, 1901, no. 1396 and 1406. Harding, August 17, 1901, no. 1562. Tower, August 26, 1901, no. 1811 and August 29, 1901, no. 1878.

172. **Cladonia squamosa** (SCOP.) HOFFM. var. **multibracteata** FLK.

On earth over rocks, locally frequent. Rainy Lake City, August 3, 1901, no. 132.

Not previously reported from Minnesota and new to North America.

173. **Cladonia squamosa** (SCOP.) HOFFM. var. **phyllocoma** RABENH.

On an old log, rare, Emo, July 23, 1901, no. 847.

174. **Cladonia subsquamosa** NYL.

On earth among rocks, rare. Emo, July 20, 1901, no. 762.

Not previously reported from Minnesota and new to the United States.

175. **Cladonia cæspiticia** (PERS.) FLK.

On rocks, rare. Rainy Lake City, August 1, 1901, no. 1085 and August 7, 1901, no. 1261. Tower, August 24, 1901, no. 1758.

176. **Cladonia delicata** (EHRH.) FLK.

On a cedar log in swamp, rare. Warroad, July 1, 1901, no. 21.

177. **Cladonia cenotea** (ACH.) SCHAER.

On earth over rocks and on old wood in swamps, frequent. Beaudette, June 18, 1901, nos. 19 and 25, June 19, 1901, no. 48 and June 24, 1901, no. 130. Emo, July 19, 1901, no. 741 and July 23, 1901, no. 850. Koochiching, July 29, 1901, no. 995. Rainy Lake City, August 7, 1901, no. 1245 and August 8, 1901, nos. 1296 and 1302. Kettle falls, August 12, 1901, no. 1399. Tower, August 27, 1901, no. 1821.

178. **Cladonia turgida** (EHRH.) HOFFM.

On earth and old wood, common on earth over rocks. Warroad, July 4, 1901, nos. 341, 350, 351 and 360. Oak island, July 8, 1901, nos. 410 and 427. Blueberry island, July 13, 1901, no. 608. Emo, July 18, 1901, no. 686 and July 20, 1901, nos. 774 and 776. Koochiching, July 25, 1901, no. 886

and July 31, 1901, no. 1035. Rainy Lake City, August 2, 1901, no. 1114 and August 7, 1901, no. 1247. Kettle falls, August 12, 1901, no. 1408 and August 13, 1901, no. 1481 and August 17, 1901, nos. 1535 and 1563. Tower, August 29, 1901, no. 1867.

179. **Cladonia cariosa** (ACH.) SPRENG.

On earth over rocks, locally frequent. Koochiching, July 26, 1901, no. 903. Tower, August 24, 1901, no. 1722 and August 27, 1901, no. 1836.

180. **Cladonia decorticata** (FLK.) SPRENG.

On earth and old wood, frequent. Flag island, July 12, 1901, nos. 530 and 553. Rainy Lake City, August 6, 1901, no. 1239. Kettle falls, August 12, 1901, no. 1382. Harding, August 16, 1901, no. 1533.

181. **Cladonia gracilis** (L.) WILLD.

On earth and old logs, frequent. Warroad, June 26, 1901, no. 198 and June 27, 1901, no. 203. Emo, July 18, 1901, no. 683. Rainy Lake City, August 1, 1901, no. 795. Harding, August 20, 1901, no. 1633. Tower, August 24, 1901, nos. 1732 and 1765.

182. **Cladonia gracilis** (L.) WILLD. var. **dilatata** (HOFFM.) WAINIO.

On earth and old logs, frequent. Beaudette, June 19, 1901, no. 37. Warroad, July 1, 1901, no. 298, July 2, 1901, no. 317, July 4, 1901, no. 353 and July 5, 1901, no. 380. Oak Island, July 8, 1901, no. 411. Flag island, July 12, 1901, no. 557. Emo, July 18, 1901, nos. 681 and 699. Harding, August 16, 1901, nos. 1525 and 1531. Tower, August 23, 1901, no. 1696.

Not previously reported from Minnesota.

183. **Cladonia gracilis** (L.) WILLD. var. **anthocephala** FLK.

On old wood and earth, frequent. Beaudette, June 19, 1901. no. 52 and June 21, 1901, no. 91. Warroad, June 26, 1901, no. 186, June 29, 1901, no. 272 and July 1, 1901, no. 315. Emo, July 19, 1901, nos. 740 and 749 and July 23, 1901, no. 832. Koochiching, July 31, 1901, no. 1040. Rainy Lake City, August 5, 1901, no. 1217. Kettle falls, August 12, 1901, nos. 1400 and 1407. Harding, August 16, 1901, no. 1521. Tower, August 23, 1901, no. 1675.

184. **Cladonia gracilis** (L.) WILLD. var. **dilacerta** FLK.

On old wood and earth, infrequent. Rainy Lake City, August 8, 1901, no. 1301. Beaudette, June 24, 1901, no. 142. Warroad, July 5, 1901, no. 385. Oak island, July 10, 1901, no. 487.

Not previously reported from Minnesota.

185. **Cladonia degenerans** (FLK.) SPRENG.

On earth over rocks, infrequent. Rainy Lake City, August 3, 1901, no. 1139, August 7, 1901, no. 1269 and August 8, 1901, no. 1303. Tower, August 24, 1901, no. 1752.

186. **Cladonia degenerans** (FLK.) SPRENG. var. **euphorea** (ACH.) FLK.

On earth over rocks, infrequent. Rainy Lake City, August 7, 1901, no. 1264. Kettle falls, August 14, 1901, no. 1465. Harding, August 17, 1901, no. 1540.

Not previously reported from Minnesota, and new to North America.

187. **Cladonia degenerans** (FLK.) SPRENG. var. **cladomorpha** (ACH.) WAINIO.

On earth and over rocks, rare. Emo, July 20, 1901, no. 763.

Not previously reported from Minnesota, and new to North America.

188. **Cladonia verticillata** HOFFM.

On earth and old wood, common especially over rocks. Oak island, July 9, 1901, no. 470 and July 10, 1901, no. 504. Koochiching, July 27, 1901, no. 930. Kettle falls, August 10, 1901, no. 1369, August 12, 1901, no. 1384 and August 13, 1901, no. 1450. Harding, August 17, 1901, no. 1540a and August 16, 1901, no. 1525a. Tower, August 24, 1901, no. 1756 and August 27, 1901, nos. 1830 and 1831.

189. **Cladonia verticillata** HOFFM. var. **evoluta** TH. FR.

On earth, frequent. Oak island, July 9, 1901, no. 461. Emo, July 20, 1901 no. 778. Kettle falls, August 10, 1901, no. 1358.

Not previously reported from Minnesota.

190. **Cladonia pyxidata** (L.) FR.

On earth especially over rocks, frequent. Blueberry island, July 13, 1901, no. 609. Koochiching, July 31, 1901, no. 1054. Tower, August 23, 1901, no. 1709.

191. **Cladonia pyxidata** (L.) FR. var. **neglecta** (FLK.) MASS.

On earth and old wood, common. Beaudette, June 21, 1901, no. 104. Warroad, June 27, 1901, no. 220 and June 29, 1901, nos. 260 and 268. Oak island, July 9, 1901, no. 467. Emo, July 23, 1901, no. 825. Koochiching, July 27, 1901, no. 964. Kettle falls, August 10, 1901, no. 1376 and August 12, 1901, no. 1381. Harding, August 16, 1901, no. 1532 and August 20, 1901, no. 1630. Tower, August 23, 1901, no. 1678 and August 27, 1901, no. 1817.

192. **Cladonia pyxidata** (L.) FR. var. **chlorophæa** FLK.

On earth and old wood, infrequent. Beaudette, June 19, 1901, no. 51. Warroad, July 4, 1901, no. 347.

193. **Cladonia fimbriata** (L.) FR.

On earth, frequent. Oak island, July 15, 1901, no. 116. Rainy Lake City, August 7, 1901, no. 1275.

194. **Cladonia fimbriata** (L.) FR. var. **prolifera** (RETZ.) MASS.

On earth in swamps, rare. Warroad, June 28, 1901, no. 239.

Not previously reported from Minnesota, and new to the United States.

195. **Cladonia fimbriata** (L.) FR. var. **cornuto-radiata** COEM.

On earth, infrequent. Kettle falls, August 14, 1901, no. 1470. Tower, August 23, 1901, no. 1687.

Not previously reported from Minnesota, and new to North America.

196. **Cladonia fimbriata** (L.) FR. var. **radiata** (SCHREB.) COEM.

On earth and old wood, infrequent. Oak island, July 9, 1901, nos. 468 and 473. Rainy Lake City, August 8, 1901, no. 1312. Kettle falls, August 10, 1901, no. 1367. Harding, August 21, 1901, no. 1667.

Not previously reported from Minnesota.

197. **Cladonia fimbriata** (L.) FR. var. **subulata** (L.) WAINIO.

On earth over rocks, rare. Tower, August 27, 1901, no. 1833.

198. **Cladonia fimbriata** (L.) FR. var. **nemoxyna** (ACH.) WAINIO.

On earth, frequent over rocks. Warroad, July 4, 1901, no. 344. Flag island, July 12, 1901, no. 529. Oak island, July 15, 1901, no. 611. Harding, August 20, 1901, no. 1639. Tower, August 23, 1901, no. 1674 and August 27, 1901, no. 1844.

199. **Cladonia fimbriata** (L.) FR. var. **apolepta** (ACH.) WAINIO.

On old wood, common. Beaudette, June 19, 1901, no. 49. Warroad, June 27, 1901, no. 208. Oak island, July 8, 1901, no. 409. Emo, July 18, 1901, no. 720 and July 23, 1901, no. 844. Koochiching, July 25, 1901, no. 862.

200. **Cladonia fimbriata** (L.) FR. var. **coniocræa** (FLK.) WAINIO.

On old wood and earth, frequent. Beaudette, June 18, 1901, nos. 11 and 13. Oak island, July 8, 1901, no. 413 and July 9, 1901, no. 472. Emo, July 17, 1901, no. 636. Rainy Lake City, August 7, 1901, no. 1265 and August 8, 1901, no. 1287. Emo, July 24, 1901, no. 856. Harding, August 16, 1901, nos. 1508 and 1534. Tower, August 24, 1901, no. 1744.

201. **Cladonia pityrea** (FLK.) FR. var. **phyllophora** (MUDD.) WAINIO.

On earth and old logs, infrequent. Oak island, July 8, 1901, no. 416 and July 15, 1901, no. 610. Emo, July 20, 1901, nos. 761 and 770.

Not previously reported from Minnesota and new to North America.

202. **Cladonia pityrea** (FLK.) FR. var. **subacuta** WAINIO.

On old wood, frequent. Emo, July 19, 1901, no. 742.

Not previously reported from Minnesota and new to North America.

203. **Cladonia botrytes** (HAG.) WILLD.

On old wood, frequent. Beaudette, June 19, 1901, no. 41. Emo, July 18, 1901, nos. 700 and 714. Koochiching, July 25, 1901, no. 871. Rainy Lake City, August 3, 1901, no. 1140. Tower, August 24, 1901, no. 1717.

204. **Bæomyces byssoides** (L.) SCHAER.

On rocks, rare. Emo, July 22, 1901, no. 817. Rainy Lake City, August 1, 1901, no. 1061, August 5, 1901, no. 1186 and August 8, 1901, no. 1293. Kettle falls, August 9, 1901, no. 1321.

205. **Bæomyces aeruginosus** (SCOP.) NYL.

On rotten wood, rare. Emo, July 18, 1901, no. 685. Koochiching, July 29, 1901, no. 1002. Kettle falls, August 15, 1901, no. 1493. Harding, August 19, 1901, no. 1578.

206. **Biatora rufonigra** TUCK.

On rocks, rare. Kettle falls, August 9, 1901, no. 1325.

207. **Biatora granulosa** (Ehrh.) Hoffm.

On earth and on cedars in swamps, rare. Blueberry island, July 13, 1901, no. 579. Koochiching, July 30, 1901, no. 1006.

208. **Biatora mutabilis** (Fée) Tuck.?

On trees locally frequent. Warroad, June 25, 1901, no. 164. Not previously reported from Minnesota, and new to the northern states.

209. **Biatora vernalis** (L.) Fr.

Frequent on mossy bases of trees, especially in cedar swamps, but also on higher ground and on dead wood and rocks.

Beaudette, June 19, 1901, no. 58, June 22, 1901, nos. 120 and and 122 and June 24, 1901, no. 134. Warroad, June 29, 1901, no. 283 and July 4, 1901, no. 361. Emo, July 18, 1901, no. 721 and July 19, 1901, nos. 730 and 757. Koochiching, July 26, 1901, no. 916 and July 30, 1901, no. 1007. Rainy Lake City, August 2, 1901, no. 1119 and August 3, 1901, no. 1150. Kettle falls, August 9, 1901, no. 1316. Harding, August 16, 1901, no. 1513 and August 19, 1901, no. 1604. Tower, August 26, 1901, nos. 1769, 1791 and 1801.

210. **Biatora sanguineoatra** Fr.

On old wood, usually with moss, rare. Koochiching, July 27, 1901, no. 962. Rainy Lake City, August 6, 1901, no. 1241 and August 8, 1901, no. 1289. Kettle falls, August 9, 1901, no. 1327, August 13, 1901, no. 1434, and August 14, 1901, no. 1468. Harding, August 20, 1901, no. 1645. Tower, August 28, 1901, no. 1855.

211. **Biatora carnulenta** Tuck.

On old wood, rare. Warroad, June 26, 1901, no. 216.
Not previously reported from Minnesota.

212. **Biatora turgidula** (Fr.) Nyl.

On dead and living cedars in swamps, rare. Beaudette, June 19, 1901, no. 66. Warroad, July 1, 1901, no. 286. Koochiching, July 30, 1901, no. 1013. Rainy Lake City, August 5, 1901, no. 1198.

213. **Biatora leucophæa** Flk.?

On cedars in swamps, rare. Warroad, June 29, 1901, no. 276.

214. **Biatora uliginosa** (Schrad.) Fr.

On earth and old wood, common. Beaudette, June 18, 1901, no. 31, June 21, 1901, no. 104 and June 22, 1901, no. 115. Warroad, July 1, 1901, no. 296. Blueberry island, July 13, 1901, no. 604. Koochiching, July 30, 1901, no. 1024. Rainy Lake City, August 2, 1901, no. 1105 and August 8, 1901, no. 1298. Kettle falls, August 9, 1901, no. 1338. Harding, August 19, 1901, no. 1600. Tower, August 28, 1901, no. 1714.

215. **Biatora fuliginea** Ach.

On an old *Polyporus* in swamp, rare. Beaudette, June 18, 1901, no. 32.

Not previously reported from Minnesota and new to the Missippi valley.

B. uliginosa (Schrad.) Fr., *B. fuliginea* Ach. and *B. asserculosum* Schrad. are very closely related if not synonyms. The last two seem to have smaller spores than the first. Spores of the plant here listed are 6–9 by 3–5 mic.

216. **Biatora flexuosa** (Fr.) Tuck.

On old wood, rare. Harding, August 21, 1901, no. 1661.

217. **Biatora myriocarpoides** (Nyl.) Tuck.

On old wood and rocks, frequent. Warroad, June 26, 1901, no. 175. Koochiching, July 31, 1901, no. 1030. Rainy Lake City, August 5, 1901, no. 1212. Harding, August 16, 1901, no. 1502, and August 20, 1901, no. 1614. Tower, August 23, 1901, nos. 1673 and 1703, and August 27, 1901, no. 1827.

218. **Biatora varians** (Ach.) Tuck.

On trees, rare. Warroad, June 27, 1901, no. 206. Oak island, July 10, 1901, no. 506.

219. **Biatora quernea** (Dicks.) Fr.

On old wood in swamps, infrequent. Warroad, June 26, 1901, no. 249. Rainy Lake City, August 7, 1901, no. 1255.

Not previously reported from Minnesota and new to the Mississippi valley.

220. **Biatora flavidolivens** Tuck.

On cedars in swamps, rare. Warroad, July 1, 1901, no. 289. Apothecia becoming black.

221. **Biatora lucida** (Ach.) Fr.

On shaded rocks, frequent. Rainy Lake City, August 5, 1901, no. 1204, and August 6, 1901, no. 1235. Kettle falls, August 9, 1901, no. 1322. Harding, August 20, 1901, no. 1647.

222. **Biatora heerii** Hepp.

On *Peltigera canina* (L.) Hoffm., rare. Tower, August 29, 1901, no. 1884.

Not previously reported from Minnesota.

223. **Biatora oxyspora** (Tul.) Tuck.

On *Parmelia borreri* Turn. on cedars in swamps, common. Warroad, June 29, 1901, no. 271, and July 1, 1901, no. 301. Oak island, July 8, 1901, nos. 397 and 417. Mainland, July 16, 1901, no. 630. Emo, July 17, 1901, no. 670. Koochiching, July 31, 1901, no. 1026. Rainy Lake City, August 7, 1901, no. 1258. Kettle falls, August 14, 1901, no. 1466. Tower, August 26, 1901, no. 1767.

224. **Biatora mixta** Fr.

On *Populus*, infrequent. Beaudette, June 21, 1901, no. 100, Warroad, June 25, 1901, no. 157.

Not previously reported from Minnesota.

225. **Biatora atropurpurea** (Mass.) Hepp.

On *Populus* and dead wood, common on the former. Warroad, June 25, 1901, no. 168 and July 2, 1901, no. 333. Oak island, July 8, 1901, no. 428. Emo, July 18, 1901, no. 689 and July 23, 1901, no. 833. Koochiching, July 26, 1901, no. 897. Rainy Lake City, August 7, 1901, no. 1263.

Hypothecium frequently brown.

226. **Biatora sphæroides** (Dicks.) Tuck.

On bases of trees, rare. Beaudette, June 19, 1901, no. 57 and June 24, 1901, no. 135. Koochiching, July 29, 1901, no. 983. Rainy Lake City, August 5, 1901, no. 1194.

227. **Biatora hypnophila** (Turn.) Tuck.

Frequent on mossy tree bases and rarely on earth. Beaudette, June 24, 1901, no. 146. Warroad, June 26, 1901, no. 181 and June 27, 1901, nos. 205 and 211. Koochiching, July 29, 1901, no. 985. Rainy Lake City, August 7, 1901, no. 1257.

228. **Biatora rubella** (EHRH.) RABENH.

On trees, common. Beaudette, June 20, 1901, nos. 78 and 80. Warroad, June 26, 1901, no. 197, June 27, 1901, no. 221, June 28, 1901, no. 238 and July 2, 1901, nos. 324 and 326. Oak island, July 9, 1901, no. 457 and July 10, 1901, no. 494. Flag island, July 12, 1901, no. 545. Koochiching, July 26, 1901, no. 892 and June 29, 1901, no. 981. Rainy Lake City, August 3, 1901, no. 1151. Kettle falls, August 13, 1901, no. 1430 and August 14, 1901, no. 1475. Harding, August 16, 1901, nos. 1498 and 1516.

229. **Biatora atrosanguinea** SCHAER.

On trees, frequent. Warroad, July 2, 1901, no. 326.

Not previously reported from Minnesota and new to North America.

230. **Biatora fuscorubella** (HOFFM.) TUCK.

On trees, common on cedars in swamps. Beaudette, June 20, 1901, no. 72 and June 22, 1901, no. 116. Warroad, June 29, 1901, nos. 264 and 284, and July 1, 1901, nos. 301 and 303. Oak island, July 8, 1901, no. 400. Emo, July 18, 1901, nos. 707 and 708, July 18, 1901, no. 712 and July 23, 1901, no. 842. Koochiching, July 30, 1901, no. 1017. Tower, August 26, 1901, no. 1770.

231. **Biatora schweinitzii** FR.

On cedars in swamps, infrequent. Oak island, July 9, 1901, no. 463. Harding, August 19, 1901, no. 1574.

Thallus, apothecia and spores unusually well developed in the first collection.

232. **Biatora atrogrisea** (DELIS.) HEPP.

On trees, rare. Warroad, June 28, 1901, no. 224 and July 2, 1901, no. 331.

233. **Biatora inundata** FR.

On rocks by water, rare. Tower, August 28, 1901, no. 1861.

234. **Biatora akompsa** TUCK.

On cedars in swamps, rare. Warroad, June 29, 1901, no. 261. Emo, July 18, 1901, no. 722.

235. **Biatora umbrina** (ACH.) TUCK. ?

On cedars in swamps, rare. Warroad, July 2, 1901, no. 334. Spores larger than usual.

236. **Biatora chlorantha** TUCK.

On balsams in swamps, rare. Beaudette, June 21, 1901, no. 97a.

Not previously reported from Minnesota.

237. **Biatora moriformis** (ACH.) TUCK.

On trees, rare. Warroad, July 2, 1901, no. 321. Tower, August 29, 1901, no. 1877.

Not previously reported from Minnesota.

238. **Lecidea goniophila** KBR.

On rocks, rare. Flag island, July 12, 1901, no. 547. Koochiching, July 29, 1901, no. 975. Tower, August 27, 1901, no. 1824.

Not previously reported from Minnesota, but perhaps should be included in *Lecidea enteroleuca* Fr.

239. **Lecidea platycarpa** ACH.

On rocks, rare. Blueberry Island, July 13, 1901, nos. 596 and 602. Emo, July 20, 1901, no. 789. Tower, August 23, 1901, no. 1681 and August 24, 1901, no. 1750.

240. **Lecidea lapicida** FR.

On rocks, rare. Emo, July 20, 1901, no. 785. Rainy Lake City, August 5, 1901, no. 1211.

241. **Lecidea enteroleuca** FR.

Common on trees and less frequent on rocks and old wood. Beaudette, June 21, 1901, no. 90. Warroad, June 26, 1901, no. 191, June 27, 1901, nos. 201 and 218, and June 28, 1901, no. 231. Oak Island, July 9, 1901, nos. 444, 462 and 481. Blueberry island, July 13, 1901, no. 601. Mainland, July 16, 1901, no. 629. Emo, July 22, 1901, nos. 798 and 818. Koochiching, July 25, 1901, nos. 884 and 890, July 26, 1901, no. 908 and July 27, 1901, nos. 950 and 954. Rainy Lake City, August 1, 1901, no. 1079, August 2, 1901, nos. 1107 and 1118 and August 8, 1901, no. 1290. Kettle falls, August 9, 1901, no. 1319. Harding, August 20, 1901, no. 1649. Tower, August 24, 1901, nos. 1753 and 1760.

242. **Lecidea enteroleuca** FR. var. **theiloplaca** TUCK.

On wet rocks, rare. Harding, August 16, 1901, no. 1524.

Greenish cast of thallus and the wet habitat are unusual for the species.

243. **Lecidea enteroleuca** FR. var. **flavida** FR.

On trees, infrequent. Warroad, June 26, 1901, no. 188 and June 27, 1901, no. 212. Rainy Lake City, August 3, 1901, no. 1143. Tower, August 28, 1901, no. 1863.

244. **Lecidea elabens** FR.

On old wood, rare. Warroad, June 26, 1901, no. 251 and July 5, 1901, no. 383. Kettle falls, August 9, 1901, no. 1329. Tower, August 23, 1901, no. 1697.

Not previously reported from Minnesota and new to the United States. Dr. T. Hedlund, who determined the plant, considers it the same as *Lecidea melancheima* Tuck.

245. **Lecidea cyrtidia** TUCK.

On rocks, rare. Rainy Lake City, August 8, 1901, no. 1308.

246. **Buellia parasema** (ACH.) TH. FR.

On trees common, especially on balsams in swamps. Beaudette, June 19, 1901, no. 63 and June 20, 1901, nos. 68 and 73. Warroad, June 24, 1901, nos. 269 and 272 and July 1, 1901, no. 290. Oak island, July 8, 1901, nos. 386 and 391. Mainland, July 16, 1901, no. 632. Emo, July 17, 1901, no. 661 and July 18, 1901, no. 702. Koochiching, July 25, 1901, no. 878. Rainy Lake City, August 2, 1901, no. 1124 and August 3, 1901, no. 1175. Kettle falls, August 9, 1901, no. 1314, August 13, 1901, no. 1445 and August 15, 1901, no. 1480. Tower, August 23, 1901, no. 1677 and August 26, 1901, no. 1786.

247. **Buellia alboatra** (HOFFM.) TH. FR. var. **saxicola** FR.

On rocks, rare. Rainy Lake City, August 3, 1901, no. 1144 and August 8, 1901, no. 1291.

248. **Buellia myriocarpa** (DC.) MUDD.

Frequent on trees and old wood, and especially common on pines. Warroad, July 3, 1901, no. 335. Oak island, July 9, 1901, no. 449. Rainy Lake City, August 7, 1901, no. 1256. Harding, August 16, 1901, no. 1515 and August 20, 1901, no. 1638. Tower, August 28, 1901, no. 1857 and August 29, 1901, no. 1876.

249. **Buellia myriocarpa** (DC.) MUDD. var. **punctiformis** HOFFM.

On old wood, rare. Oak island, July 9, 1901, no. 446. Koochiching, July 27, 1901, no. 952.

Not previously reported from Minnesota and new to North America.

250. **Buellia turgescens** (Nyl.) Tuck.

On old wood, rare. Oak island, July 9, 1901, nos. 442 and 445.

251. **Buellia schaereri** De Not.

On pines, rare. Rainy Lake City, August 6, 1901, no. 1242.

Not previously reported from Minnesota.

252. **Buellia badioatra** (Flk. Schaer.) Kbr.

On rocks, rare. Blueberry island, July 13, 1901, no. 566.

Not previously reported from Minnesota and new to the Mississippi valley.

253. **Buellia concreta** (Kbr.) Eck.

On rocks, infrequent. Oak island, July 15, 1901, no. 622. Rainy Lake City, August 5, 1901, no. 1189.

Not previously reported from Minnesota and new to the United States.

254. **Buellia obscurata** (Ach.) Eck.

On rocks, frequent. Kettle falls, August 14, 1901, no. 1472.

Not previously reported from Minnesota and new to the United States.

255. **Buellia concentrica** (Dav.) Fink.

On rocks, rare. Rainy Lake City, August 2, 1901, no. 1106. Kettle falls, August 8, 1901, no. 1313.

Not previously reported from Minnesota and new to the United States.

256. **Buellia petræa** (Flot.) Tuck.

On rocks, common. Warroad, July 4, 1901, no. 365. Flag island, July 12, 1901, no. 560. Blueberry island, July 13, 1901, no. 583. Emo, July 20, 1901, nos. 783 and 790 and July 22, 1901, nos. 794 and 804. Koochiching, July 26, 1901, no. 915. Rainy Lake City, August 3, 1901, no. 1161. Kettle falls, August 10, 1901, no. 1354. Harding, August 17, 1901, no. 1566 and August 20, 1901, no. 1642. Tower, August 24, 1901, no. 1751 and August 28, 1901, no. 1820.

257. **Buellia petræa** (Flt.) Tuck. var. **montagnæi** Tuck.

On rocks, common. Oak island, July 10, 1901, no. 493. Rainy Lake City, August 1, 1901, no. 792 and August 6, 1901,

no. 1229. Kettle falls, August 9, 1901, no. 1320. Harding, August 17, 1901, no. 1567. Tower, August 23, 1901, no. 1712.

258. **Buellia geographica** (L.) TH. FR.

On rocks, rare. Blueberry island, July 13, 1901, no. 57.

259. **Buellia saxatilis** (SCHAER.) KBR.

On *Bæomyces byssoides* (L.) Schaer., rare. Rainy Lake City, August 8, 1901, nos. 1285 and 1291.

Not previously reported from Minnesota, and new to the Mississippi valley.

260. **Buellia inquilina** TUCK.

On *Lecanora cinerea* (L.) Sommerf., rare. Warroad, July 4, 1901, no. 369.

Not previously reported from Minnesota and new to the Mississippi valley.

261. **Buellia parasitica** (FLK.) TH. FR.

On *Pertusaria communis* DC. on cedars in swamps, rare. Oak island, July 8, 1901, no. 398 and July 9, 1901, no. 460. Harding, August 20, 1901, no. 1627. Tower, August 26, 1901, no. 1792.

Not previously reported from Minnesota and new to the Mississippi valley.

262. **Buellia parmeliarum** (SOMMERF.) TUCK.

On *Parmelias* on cedars in swamps, common on *P. borreri* Turn. Beaudette, June 22, 1901, nos. 118 and 121. Warroad, July 1, 1901, no. 311. Oak island, July 8, 1901, nos. 397 and 403. Kettle falls, August 13, 1901, no. 1446. Harding, August 16, 1901, nos. 1501 and 1509. Tower, August 28, 1901, no. 1854.

263. **Buellia glaucomaria** (NYL.) TUCK.

On *Pertusaria* sp. on birch, locally common. Warroad, July 5, 1901, no. 378.

Not previously reported from Minnesota and new to the Mississippi valley.

264. **Lecanactis chloroconia** TUCK.

On cedars, rare. Emo, July 19, 1901, no. 759.

Not previously reported from Minnesota and new to the Mississippi valley.

265. **Melaspilea arthonioides** (Fée) Nyl.

On trees, infrequent. Warroad, June 26, 1901, nos. 176 and 178. Flag island, July 12, 1901, no. 558. Rainy Lake City, August 3, 1901, no. 1141. Kettle falls, August 13, 1901, no. 1833.

266. **Opegrapha varia** (Pers.) Fr.

On trees, especially common on cedars in swamps. Beaudette, June 18, 1901, no. 34. Warroad, July 2, 1901, no. 330. Oak island, July 10, 1901, no. 498. Emo, July 17, 1901, no. 674. Koochiching, July 26, 1901, no. 913, July 27, 1901, no. 966 and July 29, 1901, no. 986. Rainy Lake City, August 3, 1901, no. 1146. Kettle falls, August 13, 1901, nos. 1440 and 1447. Tower, August 26, 1901, no. 1775.

267. **Opegrapha quaternella** Nyl.

On *Peltigera aphthosa* (L.) Hoffm., rare. Emo, July 23, 1901, no. 838.

Not previously reported from Minnesota.

268. **Graphis scripta** (L.) Ach.

On trees, common. Beaudette, June 18, 1901, no. 15. Warroad, July 2, 1901, no. 318. Oak island, July 8, 1901, nos. 420 and 431. Emo, July 17, 1901, nos. 640 and 641. Koochiching, July 26, 1901, no. 926. Rainy Lake City, August 3, 1901, no. 1163. Kettle falls, August 13, 1901, nos. 1424 and 1435. Harding, August 19, 1901, no. 1570 and August 20, 1901, no. 1632. Tower, August 26, 1901, no. 1803.

269. **Graphis scripta** (L.) Ach. var. **recta** (Humb.) Nyl.

On trees, usually birch, rare. Oak island, July 8, 1901, no. 429. Emo, July 23, 1901, no. 824. Kettle falls, August 13, 1901, no. 1442. Emo, July 19, 1901, no. 737. Tower, August 29, 1901, no. 1873.

270. **Arthonia patellulata** Nyl.

On *Populus*. Part of material recorded as *Biatora atropurpurea* (Mass.) Hepp. belongs here. Needs more study.

271. **Arthonia lecideella** Nyl.

On trees, frequent. Beaudette, June 18, 1901, no. 3. Warroad, June 25, 1901, nos. 151 and 158, June 28, 1901, no. 235 and July 2, 1901, no. 320. Emo, July 17, 1901, no. 659. Koochiching, July 25, 1901, nos. 858 and 883. Rainy Lake City, August 5, 1901, no. 1185. Harding, August 19, 1901, no. 1593. Tower, August 23, 1901, no. 1670.

272. **Arthonia dispersa** (SCHRAD.) NYL.

On trees, common especially on *Acer spicatum* Lam. Beaudette, June 24, 1901, no. 137. Warroad, June 26, 1901, no. 194. Koochiching, July 25, 1901, no. 872. Rainy Lake City, August 3, 1901, no. 1142 and August 5, 1901, no. 1181. Harding, August 17, 1901, no. 1554. Tower, August 26, 1901, no. 1782.

273. **Arthonia convexella** NYL.

On balsams, rare. Beaudette, June 21, 1901, no. 97.

Not previously reported from Minnesota and new to North America.

274. **Arthonia punctiformis** ACH.

On trees, locally frequent. Emo, July 19, 1901, no. 758.

275. **Arthonia radiata** (PERS.) TH. FR.

On trees, rare. Beaudette, June 20, 1901, no. 85 and June 24, 1901, no. 137a. Warroad, June 26, 1901, no. 242. Oak island, July 10, 1901, no. 496. Emo, July 17, 1901, nos. 663 and 668 and July 18, 1901, no. 708. Koochiching, July 30, 1901, no. 1016.

276. **Arthonia radiata** (PERS.) TH. FR. var. **swartziana** (ACH.) WILLEY.

On balsams in swamps, frequent. Rainy Lake City, August 3, 1901, no. 1173. Tower, August 28, 1901, no. 1864.

Not previously reported from Minnesota.

277. **Acolium tigillare** (ACH.) DE NOT.

On old wood, rare. Oak island, July 8, 1901, nos. 389 and 394.

278. **Calicium trichiale** ACH.

On cedars in swamps, rare. Oak island, July 9, 1901, no. 453. Rainy Lake City, August 7, 1901, no. 1266.

279. **Calicium trichiale** ACH. var. **cinereum** NYL.

On trees, frequent on pines. Beaudette, June 19, 1901, no. 55. Mainland, July 16, 1901, no. 626. Emo, July 19, 1901, no. 725. Koochiching, July 30, 1901, no. 1004. Kettle falls, August 13, 1901, no. 1436.

280. **Calicium phæocephalum** (TURN.) TURN. and BORR.

On cedars in swamps, frequent. Beaudette, June 20, 1901, no. 83. Emo, July 19, 1901, no. 745.

Not previously reported from Minnesota and new to the Mississippi valley.

281. **Calicium phæocephalum** (TURN.) TURN. and BORR. var. **trabinellum** FR.

On cedars and old wood in swamps, frequent. Beaudette, June 20, 1901, no. 27. Emo, July 19, 1901, nos. 729 and 755. Koochiching, July 29, 1901, no. 974.

Not previously reported from Minnesota and new to North America.

282. **Calicium chrysocephalum** (TURN.) ACH.

On pines, cedars and old wood, infrequent. Emo, July 17, 1901, no. 653 and July 23, 1901, no. 841. Kettle falls, August 14, 1901, no. 1477 and August 15, 1901, no. 1490.

283. **Calicium parietinum** ACH.

On old wood, frequent. Beaudette, June 20, 1901, no. 79 and June 22, 1901, no. 116. Warroad, June 27, 1901, nos. 210, 222 and 223, June 28, 1901, nos. 227 and 230 and July 1, 1901, no. 295. Harding, August 16, 1901, no. 1497, August 19, 1901, no. 1599 and August 20, 1901, no. 1643. Tower, August 28, 1901, no. 1856.

284. **Calicium polyporæum** NYL.

On *Polyporus* on *Populus*, frequent. Emo, July 24, 1901, nos. 854 and 857. Koochiching, July 26, 1901, no. 921. Kettle falls, August 9, 1901, no. 1348. Harding, August 19, 1901, no. 1588. Tower, August 29, 1901, no. 1883.

285. **Calicium lucidum** (TH. FR.) FINK.

On pines, cedars and old wood, infrequent. Warroad, June 28, 1901, no. 243. Rainy Lake City, August 5, 1901, nos. 1200 and 1254. Harding, August 20, 1901, no. 1626. Tower, August 29, 1901, no. 1886.

286. **Calicium trachelinum** ACH.

On dead cedars, wood in swamps, common. Warroad, July 2, 1901, no. 329. Oak island, July 8, 1901, no. 401. Koochiching, July 26, 1901, no. 920. Rainy Lake City, August 5, 1901, nos. 1197 and 1202.

287. **Calicium trabellinum** (SCHAER.) KBR.

On pine stumps, locally frequent. Kettle falls, August 9, 1901, no. 1328. Harding, August 17, 1901, no. 1559.

Not previously reported from Minnesota.

288. **Calicium quercinum** Pers.

On old wood, infrequent. Warroad, June 28, 1901, no. 252, and June 29, 1901, no. 259. Tower, August 24, 1901, no. 1742.

289. **Calicium quercinum** Pers. var. **lentibulare** (Ach.) Nyl.

On pines, cedars and old wood, infrequent. Beaudette, June 21, 1901, no. 94. Warroad, June 28, 1901, no. 255. Oak island, July 8, 1901, no. 390, and July 9, 1901, no. 443. Koochiching, July 27, 1901, no. 957. Rainy Lake City, August 5, 1901, no. 1209. Kettle falls, August 13, 1901, no. 1444.

Not previously reported from Minnesota and new to the Mississippi valley.

290. **Calicium pusillum** Flk.

On dead cedars, in swamps, locally common. Rainy Lake City, August 5, 1901, no. 1205. Tower, August 26, 1901, no. 1785.

291. **Calicium turbinatum** Pers.

On *Pertusaria communis* DC. on cedars in swamps, frequent. Beaudette, June 20, 1901, no. 77. Warroad, July 1, 1901, no. 303. Oak island, July 9, 1901, no. 432. Emo, July 17, 1901, no. 660. Koochiching, July 31, 1901, no. 1033. Kettle falls, August 13, 1901, no. 1428. Harding, August 21, 1901, no. 1656. Tower, August 26, 1901, no. 1809.

292. **Coniocybe pallida** (Pers.) Fr.

On trees, frequent. Beaudette, June 21, 1901, no. 96. Warroad, June 28, 1901, no. 225 and June 29, 1901, no. 266. Emo, July 18, 1901, nos. 704 and 705 and July 19, 1901, no. 753. Koochiching, July 29, 1901, no. 987. Rainy Lake City, August 3, 1901, no. 1152. Kettle falls, August 13, 1901, no. 1443. Harding, August 9, 1901, no. 1598.

293. **Endocarpon miniatum** (L.) Schaer.

On rocks, locally common. Emo, July 22, 1901, no. 800.

294. **Endocarpon miniatum** (L.) Schaer. var. **complicatum** Schaer.

On rocks frequently wet, common. Oak island, July 10, 1901, no. 507 and July 11, 1901, no. 525. Emo, July 22, 1901, no. 799. Koochiching, July 26, 1901, no. 905. Rainy Lake City, August 8, 1901, no. 1278. Kettle falls, August 9,

1901, no. 1339 and August 13, 1901, no. 1411. Harding, August 20, 1901, no. 1625. Tower, August 26, 1901, no. 1780.

295. **Endocarpon fluviatile** DC.

On wet rocks, locally common. Koochiching, July 26, 1901, no. 902. Rainy Lake City, August 6, 1901, no. 1237. Harding, August 21, 1901, no. 1663.

296. **Endocarpon arboreum** SCHWEIN.

On trees, rare. Rainy Lake City, August 8, 1901, no. 1155.

297. **Endocarpon pusillum** HEDW. var. **garovaglii** KPH.

On earth, rare. Tower, August 27, 1901, no. 1838.

298. **Thelocarpon prasinellum** NYL.

On rocks, rare. Kettle falls, August 10, 1901, no. 1355.

299. **Staurothele umbrina** (WAHL.) TUCK. var. **clopima** (WHLNB.) NYL.

On rocks by water, common. Koochiching, July 26, 1901, no. 910 and July 30, 1901, no. 1015. Rainy Lake City, August 1, 1901, no. 1080. Kettle falls, August 15, 1901, no. 1491. Harding, August 25, 1901, no. 1646. Tower, August 28, 1901, no. 1845.

300. **Sagedia oxyspora** (NYL.) TUCK.

Common on birch. Warroad, June 25, 1901, no. 193 and June 21, 1901, no. 204. Emo, July 17, 1901, no. 665 and July 19, 1901, no. 724. Rainy Lake City, August 2, 1901, no. 1113. Kettle falls, August 15, 1901, no. 1492. Harding, August 16, 1901, no. 1522. Tower, August 26, 1901, no. 1789.

301. **Verrucaria epigæa** (PERS.) ACH.

On earth, rare. Rainy Lake City, August 5, 1901, no. 1201. Harding, August 16, 1901, no. 1523.

302. **Verrucaria nigrescens** PERS.

On rocks, frequent. Oak island, July 9, 1901, no. 436. Koochiching, July 27, 1901, no. 953. Harding, Angust 16, 1901, no. 1530.

303. **Verrucaria viridula** ACH.

On rocks by water, frequent. Koochiching, July 27, 1901, no. 955. Harding, August 21, 1901, no. 1657. Tower, August 28, 1901, no. 1847.

304. **Verrucaria viridula** Ach. var. **subfuscella** (Nyl.) Fink.

On perpendicular rocks, rare. Rainy Lake City, August 7, 1901, no. 1248.

Not previously reported from Minnesota and new to the Mississippi valley.

305. **Verrucaria fuscella** Fr.

On rocks by water, rare. Koochiching, July 27, 1901, no. 960.

306. **Pyrenula punctiformis** (Ach.) Naeg. var. **fallax** Nyl.

On birch, common. Beaudette, June 20, 1901, no. 81 and June 21, 1901, no. 89. Emo, July 18, 1901, no. 690. Koochiching, July 25, 1901, no. 898. Rainy Lake City, August 5, 1901, no. 1178.

307. **Pyrenula thelena** (Ach.) Tuck.

On birch, locally common. Beaudette, June 21, 1901, no. 103.

308. **Pyrenula cinerella** (Flt.) Tuck. var. **quadriloculata** Fink.

On birch, locally common. Flag island, July 12, 1901, no. 550.

309. **Pyrenula leucoplaca** (Wallr.) Kbr.

On trees, abundant on *Populus*. Beaudette, June 24, 1901, no. 138 and June 21, 1901, no. 105. Warroad, June 24, 1901, no. 149. Flag island, July 12, 1901, no. 549. Emo, July 18, 1901, no. 682. Koochiching, July 21, 1901, no. 877 and July 26, 1901, no. 914. Rainy Lake City, August 6, 1901, no. 1236. Harding, August 16, 1901, no. 1520 and August 19, 1901, nos. 1582 and 1591. Tower, August 26, 1901, nos. 1796 and 1813.

310. **Pyrenula leucoplaca** (Wallr.) Kbr. var. **pluriloculata** Fink.

On trees, common. Beaudette, June 21, 1901, no. 110. Warroad, June 27, 1901, nos. 200 and 209 and June 28, 1901, no. 229. Flag island, July 12, 1901, nos. 534 and 537. Koochiching, July 25, 1901, nos. 862 and 980. Rainy Lake City, August 3, 1901, no. 1487. Kettle falls, August 13, 1901, no. 1419 and August 15, 1901, no. 1489. Harding, August 17, 1901, no. 1545 and August 19, 1901, no. 1609.

XIX. THE UMBELLALES OF MINNESOTA.

W. A. Wheeler.

This catalog of the Minnesota Umbellales is a result of the examination and redetermination of all the Minnesota specimens in the University Herbarium. The largest family in the order, the Umbelliferæ, was in so confused a state before the publication of the monograph on the order by Coulter and Rose[1] that it has been thought desirable to publish a revised list of the Minnesota Umbelliferæ based upon this monograph, and to include in the list the two other families in the order.

Upham, in his catalog of Minnesota plants, lists five species of Araliaceæ, thirty-two species and varieties of Umbelliferæ, and eight species of Cornaceæ.

The number of Araliaceæ reported from Minnesota in this list, as represented by specimens in the University Herbarium, remains unchanged.

Of the Umbelliferæ there are in the University Herbarium authentic Minnesota specimens of twenty-four species and varieties, of which twenty-two are native and two are introduced. One additional native species is represented by specimen in the National Herbarium. Seven species and varieties reported by Upham are not represented by Minnesota specimens, to the author's knowledge, in any herbarium. The latter are therefore of doubtful occurrence. They are, however, listed here, with an explanatory note to each, giving the authority upon which the report is based.

Of the eight species of Cornaceæ reported by Upham, six are represented by specimens in the University Herbarium. One has been added that was not included by Upham. There are, therefore, seven species known to Minnesota.

In this list individual collections are cited only where the species is poorly represented by specimens from the state. The citations of specimens from the National Herbarium have been taken directly from Coulter and Rose.

[1] Contributions U. S. National Herbarium, Vol. VII., No. 1, December 31, 1900.

ARALIACEÆ.

Aralia racemosa L. Sp. Pl. 273. 1753. American spikenard.

Common in woods throughout.

Herb.: Collections from all parts of the state.

Aralia nudicaulis L. Sp. Pl. 274. 1753. Wild sarsaparilla.

Common in woods throughout.

Herb.: Collections from all parts of the state.

Aralia hispida Vent. Hort. Cels. *pl. 41.* 1800. Bristly sarsaparilla.

Common in the northeastern part of Minnesota.

Herb.: Bailey 341, St. Louis river; Arthur 47, Vermilion lake; J. Scofield, Carlton; T. S. Roberts, Duluth; Sandberg, Tower, Thomson and Two Harbors.

Panax quinquifolium L. Sp. Pl. 1058. 1753. Ginseng.

Aralia quinquefolia Dec. & Pl. Rev. Hort. 104. 1854.

At one time common nearly throughout Minnesota. The roots have been dug in so large quantities to supply the demand for export that the plant is at present quite rare.

Herb.: Lyon 210, Mayville, Houston county; Wheeler 469, Jefferson, Houston county; Ballard, 334, Belle Plain; Sheldon, 403, Taylor 711, Madison lake; Aiton, Sandberg, Hennepin county; Holzinger, Winona; Sandberg, Vasa.

Panax trifolium L. Sp. Pl. 1059. 1753. Dwarf ginseng.

Aralia trifolia Dec. & Pl. Rev. Hort. 104. 1854.

Rare in woods east.

Herb.: Sandberg, Carlton county.

UMBELLIFERÆ.

Hydrocotyle umbellata L. Sp. Pl. 1: 234. 1753. Marsh pennywort.

Reported from the north shore of lake Superior by Upham. The specimen in the University Herbarium so labeled is *Mitella nuda* L. This species of *Hydrocotyle* probably does not occur in Minnesota.

Hydrocotyle americana L. Sp. Pl. 1: 234. 1753. Marsh pennywort.

Rare in moist soil east. Plentiful on the Wisconsin side of the St. Croix river near St. Croix Falls.

Herb.: Sandberg, Chisago county; Wheeler 314, Houston county.

Sanicula marylandica L. Sp. Pl. **1**: 235. 1753. Black snakeroot.

In woods throughout, common.

Herb.: Numerous collections from all parts of state.

Sanicula gregaria BICKNELL, Bull. Torr. Club, **22**: 354. 1895. Yellow-flowered snakeroot.

In woods south.

Herb.: Burglehaus, Hennepin county; Ballard 390, Scott county; Sheldon, Milaca; Sheldon 141, Madison lake; Rosendahl 562, Wheeler 177, Houston county; Holzinger, Winona.

Nat. Herb.: Mearns, Fort Snelling.

Sanicula canadensis L. Sp. Pl. **1**: 235. 1753. Short-styled snakeroot.

In woods south.

Herb.: Lyon 260, Houston county; Sheldon 983, Brown county.

Sanicula trifoliata BICKNELL, Bull. Torr. Club, **22**: 359. 1895. Large-fruited snakeroot.

Rare in woods southeast.

Herb.: Lyon 214, Houston county; Rosendahl 588, Fillmore county.

Eryngium yuccifolium MICHX. Fl. Bor. Am. **1**: 164. 1803. Button snakeroot.

Eryngium aquaticum L. Sp. Pl. ed. 2, 336, 1762 in part, not ed. 1.

Frequent south.

Herb.: Sandberg, Cannon falls; Sheldon, Sleepy Eye, Waseca county; Ballard, Nicollet county; Holzinger, Winona; Taylor, Janesville; Aiton, Hennepin county.

Washingtonia claytoni (MICHX.) BRITTON, Ill. Fl. **2**: 530. 1897. Sweet cicely.

Osmorrhiza brevistylis DC. Prodr. **4**: 232. 1830.

Myrrhis claytoni MICHX. Fl. Bor. Am. **1**: 170. 1803.

Common in woods throughout.

Herb.: Numerous specimens.

Washingtonia longistylis (TORR.) BRITTON, Ill. Fl. 2: 530. 1897. Sweet cicely.

Osmorrhiza longistylis DC. Prodr. 4: 232. 1830.

Myrrhis aristata (THUNB.) MACM. Met. Minn. Val. 398. 1892.

Common in woods throughout.

Herb.: Numerous specimens.

Conium maculatum L. Sp. Pl. 243. 1753. Poison hemlock.

A European species reported from the Red river valley by Upham. There are no Minnesota specimens in the University Herbarium.

Zizia aurea (L.) KOCH, Nov. Act. Caes. Leop. Acad. 12: 129. 1824. Early meadow-parsnip.

Thaspium aureum apterum GRAY, Man. ed. 2, 156. 1856.

Very common throughout except northeast. Confused by many authors and collectors with *Thaspium trifoliatum aureum* (Nutt.) Britton and *Thaspium barbinode* (Michx.) Nutt.

Herb.: Very numerous collections.

Zizia cordata (WALT.) KOCH in DC. Prodr. 4: 111. 1830. Heart-leaved meadow-parsnip.

Thaspium trifoliatum apterum GRAY, Man. ed. 2, 156. 1856.

Thaspium aureum cordatum (WALT.) B.S.P. Cat. N. Y. 1888.

Common throughout except northeast.

Herb.: Numerous collections.

Cicuta maculata L. Sp. Pl. 1: 256. 1753. Water hemlock.

Cicuta virosa maculata C. & R. Rev. N. A. Umbell. 131. 1888.

Common throughout, especially south.

Herb.: Numerous specimens.

Cicuta bulbifera L. Sp. Pl. 1: 255. 1753. Bulb-bearing water-hemlock.

Common in moist soil throughout.

Herb.: Many collections.

Deringa canadensis (L.) KUNTZE, Rev. Gen. Pl. 1: 266. 1891. Honewort.

Cryptotænia canadensis DC. Prodr. 4: 119. 1830.

Common in woods throughout.

Herb.: Numerous collections.

Carum carui L. Sp. Pl. 1: 263. 1753. Garden caraway.

Escaped from cultivation in some parts of state.

Herb.: Moyer, Montevideo; Wickersheim, Lincoln county; Sheldon, 2610, Mille Lacs Reserv.; Frost 124, Meeker county.

Tænidia integerrima (L.) DRUDE, Engl. & Prantl. Nat. Pfl. 3[8]: 195. 1898. Yellow pimpernel.

Pimpinella integerrima GRAY, Proc. Am. Acad. 7: 345. 1868.

Zizia integerrima DC. Mem. Soc. Phys. Genev. 4: 493. 1828.

Frequent southeast.

Herb.: Wheeler, Houston county; Sandberg, Belle creek.

Nat. Herb.: Holzinger, Winona.

Sium cicutæfolium GMELIN, Syst. 2: 482. 1791. Water-parsnip.

Sium lineare MICHX. Fl. Bor. Am. 1: 167. 1803.

Common in swamps throughout.

Herb.: Numerous collections.

Sium carsoni DURAND; A. Gray, Man. ed. 5, 196. 1867. Carson's water-parsnip.

Probably rare east.

Nat. Herb.: Sandberg, near Minneapolis.

Berula erecta (HUDS.) COVILLE, Contr. Nat. Herb. 4: 115. 1893. Small water-parsnip.

Berula angustifolia M. & K. Deutsch. Fl. 2: 433. 1826.

Sium angustifolium L. Sp. Pl. ed. 2, 2: 1672. 1763.

Springs and streams south.

Herb.: Collections from the southern half of the state.

Æthusa cynapium L. Sp. Pl. 256. 1753. Fool's parsley.

A European species reported by Upham as occurring in Wabasha and Nicollet counties. There are no Minnesota collections in the University Herbarium.

Thaspium trifoliatum aureum (NUTT.) BRITTON, Mem. Torr. Club, 5: 240. 1894. Meadow-parsnip.

Thaspium aureum NUTT. Gen. 1: 196. 1818.

Thaspium aureum trifoliatum C. & R. Bot. Gaz. 12: 136. 1887.

This species and variety have been included in many reports of Minnesota plants. There are, however, no authentic Min-

nesota specimens in the University Herbarium. They have previously been confused with the two Minnesota species of *Zizia*.

Thaspium barbinode (MICHX.) NUTT. Gen. Pl. **1**: 196. 1818. Hairy-jointed meadow-parsnip.

Infrequent south.

Herb.: Ballard 971, Nicollet county; Sheldon 791, 989, Sleepy Eye, 1180, New Ulm; Holzinger, Winona.

Conioselinum chinense (L.) B.S.P. Prel. Cat. N. Y. 22. 1888. Hemlock parsley.

Selinum canadense MICHX. Fl. Bor. Am. **1**: 165. 1803.

Reported by Upham as occurring along the upper Mississippi river. There are no authentic collections known from Minnesota. Its range apparently does not extend so far west as this state.

Angelica villosa (WALT.) B.S.P. Prel. Cat. N. Y. 22. 1888. Pubescent angelica.

Archangelica hirsuta T. & G. Fl. **1**: 622. 1840.

Reported by Upham as collected in Wabasha and Anoka counties. These collections were probably incorrectly determined as Minnesota is rather too far north to be included in the natural range of this species.

Angelica atropurpurea L. Sp. Pl. **1**: 251. 1753. Great angelica.

Archangelica atropurpurea HOFF. Umbel. 162. 1814.

In moist soil, east.

Herb.: Several collections from eastern Minnesota.

Cymopterus acaulis (PURSH) RYDB. Bot. Surv. Neb. **3**: 38. 1894. Plains cymopterus.

Cymopterus glomeratus DC. Prodr. **4**: 204. 1830.

Reported by Upham as collected by Lapham in the Red river valley. Its occurrence, however, is rather doubtful.

Polytænia nuttalli DC. Coll. Mem. **5**: 54. 1829.

In dry soil, southeast.

Herb.: Hvoslef, Lanesboro; Sandberg, Vasa.

Oxypolis rigidior (L.) RAF. in Seringe, Bull. Bot. 218. 1830. Cowbane.

Archemora rigida DC. Prodr. **4**: 188. 1830.

Tiedemannia rigida C. & R. Bot. Gaz. **12**: 74. 1887.

In swamps southeast.

Herb.: Lyon, Houston county; Oestlund, Hennepin county; Sandberg, Goodhue county; Hvoslef, Lanesboro.

Nat. Herb.: Mearns 280, Fort Snelling.

Lomatium orientale C. &. R. Cont. U. S. Nat. Herb. **7**: 220. 1900. Hog's fennel.

Peucedanum nudicaule NUTT. in part and of all late authors.

In dry soil southwest.

Herb.: Moyer, Montevideo; Menzel, Pipestone; Wickersheim, Lincoln county: Nels Nelson, Montevideo; Payne, Appleton.

Pastinaca sativa L. Sp. Pl. **1**: 262. 1753. Common parsnip.

Escaped from cultivation throughout.

Herb.: Specimens from scattered localities.

Heracleum lanatum MICHX. Fl. Bor. Am. **1**: 166. 1803. Cow-parsnip.

Common in moist soil throughout.

Herb.: Numerous collections from all parts.

Daucus carota L. Sp. Pl. **1**: 242. 1753. Common carrot.

Occasionally escaped from cultivation throughout.

CORNACEÆ.

Cornus canadensis L. Sp. Pl. 117. 1753. Dwarf cornel.

Common in woods north and occasional southeast.

Herb.: Numerous collections from the northern part of the state and a few collections along the Mississippi river south.

Cornus florida L. Sp. Pl. 117. 1753. Flowering dogwood.

Reported from Minnesota by Upham but probably does not occur here.

Cornus circinata L'HER. Cornus, 7, *pl. 3*. 1788. Round-leaved dogwood.

Common throughout.

Herb.: Numerous collections.

Cornus amonum MILL. Gard. Dict. ed. 8, No. 5. 1768.

Cornus sericea L. MANT. **2**: 199. 1771.

Infrequent south.

Herb.: Lyon 351, Jefferson, Houston county; Rosendahl 610, Spring Grove, Houston county; Sheldon, 390, Madison lake; Ballard, 353, Scott county.

Cornus asperifolia Michx. Fl. Bor. Am. **1**: 93. 1803. Rough-leaved dogwood.

Reported from southern Minnesota. There are no authentic specimens in the University Herbarium.

Cornus baileyi Coulter & Evans, Bot. Gaz. **15**: 37. 1890. Bailey's dogwood.

Frequent throughout.

Herb.: Collections from all parts of state.

Cornus stolonifera Michx. Fl. Bor. Am. **1**: 92. 1803. Red-twigged dogwood.

Common throughout.

Herb.: Numerous collections.

Cornus candidissima Marsh. Arb. Am. 35. 1785. Panicled dogwood.

Cornus paniculata L'Her. Cornus, 9, *pl. 15*. 1788.

Common throughout.

Herb.: Numerous collections.

Cornus alternifolia L. f. Suppl. 125. 1781. Alternate-leaved dogwood.

Frequent east.

Herb.: Collections from eastern half of state.

XX. THE PTERIDOPHYTES OF MINNESOTA.

HAROLD L. LYON.

In his "Catalogue of the Flora of Minnesota" (1884) Upham reports sixty-two Pteridophytes as occurring in the state; to this list Cheney * has added two species, and Arthur,† MacMillan,‡ Holzinger,§ Lloyd,‖ and Wheeler ¶ one each, making a total of sixty-nine species and varieties.

The following catalog is mainly a record of the Pteridophytes in the herbarium of the University which have been collected in Minnesota. These specimens, as redetermined by the writer, represent sixty species and varieties, five of which have not previously been reported from the state.

PTERIDOPHYTA.

Order LYCOPODIALES.

Family LYCOPODIACEÆ.

Lycopodium selago L. Sp. Pl. 1102. 1753. Fir club-moss.

Reported from the north shore of Lake Superior by Upham, but there are no specimens in the herbarium.

Lycopodium porophilum LLOYD & UNDERW. Bull. Torr. Club, **27**: 150. 1900.

On sandstone ledges. Not previously reported from Minnesota.

Herb.: Rosendahl, Minneapolis; Leiberg, Minneopa Falls.

Lycopodium lucidulum MICHX. Fl. Bor. Am. **2**: 284. 1803. Shining club-moss.

Frequent in northern Minnesota, in deep, damp woods.

Herb.: Sandberg, Aitkin Co.; Taylor, Taylor's falls; Hall, Devils Track river; Bailey, St. Louis river; MacMillan, Brand & Lyon, North-South lake portage.

*Trans. Wis. Acad. Scien. **9**: 247, 248. 1893.
†Geol. and Nat. Hist. Survey, Bull. No. 3, 24. 1887.
‡Bull. Torr. Bot. Club, **18**: 13. 1891.
§Minn. Bot. Studies, **1**: 518. 1896.
‖Bull. Torr. Bot. Club, **26**: 566. 1899.
¶Minn. Bot. Studies, **2**: 370. 1900.

Lycopodium inundatum L. Sp. Pl. 1102. 1753. Bog club-moss.

In swamps and bogs. Rare.

Herb.: Wheeler, Echo lake.

Lycopodium obscurum L. Sp. Pl. 1102. 1753. Ground pine.

Common throughout northern Minnesota.

Herb.: Many specimens.

Lycopodium annotinum L. Sp. Pl. 1103. 1753. Stiff club-moss.

Range about the same as the last, less frequent.

Herb.: Many specimens among which is to be found the var. *pungens*.

Lycopodium clavatum L. Sp. Pl. 1101. 1753. Club-moss.

Frequent in the northern part of state.

Herb.: Anderson, Gull lake; MacMillan & Sheldon, Lake Kilpatrick; Arthur, Vermilion lake; Roberts, French river; Sheldon, Milaca; Lugger, Tower.

Lycopodium sabinæfolium WILLD. Sp. Pl. **5**: 20. 1810. Cedar-like club-moss.

Reported by Upham, but there are no specimens in the Herbarium to verify the report.

Lycopodium complanatum L. Sp. Pl. 1104. 1753. Trailing club-moss.

Frequent throughout northern part of state.

Herb.: Well represented.

Lycopodium tristachyum PURSH, Fl. Am. Sept. **2**: 653. 1814.

Lycopodium chamæcyparissus A. BR.; Doell. Rhein. Fl. 36. 1843.

Range probably coextensive with the last.

Herb.: Anderson, Gull lake.

Family SELAGINELLACEÆ.

Selaginella selaginoides (L.) LINK, Fil. Hort. Berol. 158. 1841. Low selaginella.

Rare, north.

Herb.: Cheney, Grand Marais.

Selaginella rupestris (L.) SPRING in Mart. Fl. Bras. **1**: Part 2, 118. 1840. Rock selaginella.

Frequent in dry situations throughout.

Herb.: Many specimens.

Family ISOETACEÆ.

Isoetes lacustris L. Sp. Pl. 1100. 1753. Lake quillwort.

Probably occurs quite commonly in lakes of northern Minnesota. Not previously reported from the state.

Herb.: MacMillan, Brand and Lyon, Devil's Track lake and Hungry Jack lake, Cook county.

Isoetes tuckermani A. Br.; A. Gray, Man. Ed. 5, 676. 1867.

Known to occur in but one lake. Not previously reported from Minnesota.

Herb.: Wheeler, Echo lake.

Isoetes echinospora braunii (Durieu) Engelm.; A. Gray, Man. Ed. 5, 676. 1867.

With *Isoetes lacustris*, but more frequent.

Herb.: Arthur, Vermilion lake; MacMillan, Brand and Lyon. Many specimens from lakes of Cook county.

Isoetes echinospora boottii (A. Br.) Engelm. A. Gray, Man. Ed. 5, 676. 1867. With *Isoetes tuckermani*.

Not previously reported from the state.

Herb.: Wheeler, Echo lake.

The species of *Isoetes* were determined by A. A. Eaton.

Order EQUISETALES.

Family EQUISETACEÆ.

Equisetum arvense L. Sp. Pl. 1061. 1753. Field horsetail.

Common in sandy soil throughout the state.

Herb.: Well represented by specimens.

Equisetum pratense Ehrh. Hanov. Mag. 138. 1784. Thicket horsetail.

Rare, south.

Herb.: Lyon, Winnebago valley, Houston Co.

Equisetum sylvaticum L. Sp. Pl. 1061. 1753. Wood horsetail.

Throughout the state, preferring light soil in moist woods and thickets.

Equisetum fluviatile L. Sp. Pl. 1062. 1753. Swamp horsetail.

In swamps and along borders of lakes and streams throughout the state.

Herb.: Many specimens.

Equisetum robustum A. Br.; Engelm. Amer. Jour. Sci. **46**: 88. 1844. Stout scouring-rush.

Reported from Thompson by Holzinger.

Herb.: There are no specimens in the herbarium.

Equisetum hiemale L. Sp. Pl. 1062. 1753. Common scouring-rush.

Frequent throughout the state.

Herb.: Many specimens.

Equisetum lævigatum A. Br.; Engelm. Amer. Jour. Sci. **46**: 87. 1844.

Frequent in clay soil.

Herb.: Several collections.

Equisetum variegatum Schleich. Cat. Pl. Helvet. 27. 1817. Variegated scouring-rush.

Infrequent.

Herb.: Butters, Detroit lake.

Equisetum scirpoides Michx. Fl. Bor. Am. **2**: 281. 1803. Sedge-like scouring-rush.

Infrequent.

Herb.: Ballard, Lake Kilpatrick; Campbell, Grand Lake, Stearns Co.

Order FILICALES.

Family OPHIOGLOSSACEÆ.

Ophioglossum vulgatum L. Sp. Pl. 1062. 1753. Adder's-tongue.

Reported by Upham from Lake of the Woods, there are no Minnesota specimens in the herbarium; the plant, however, undoubtly occurs in the northern part of the state.

Botrychium lunaria (L.) Swz. Schrad. Journ. Bot. **2**: 110. 1800. Moonwort.

Infrequent, northern Minnesota. Cool, damp woods.

Herb.: Cheney, Brule river; Hibbard, Grand Marais; MacMillan and Sheldon, Lake of the Woods.

Botrychium simplex E. Hitchcock, Amer. Jour. Sci. **6**: 103. 1823. Little grape-fern.

Reported by Upham from Thompson, Carlton Co.

Herb.: No specimens from Minnesota.

Botrychium obliquum MUHL.; Willd. Sp. Pl. 5: 63. 1810.

Infrequent in damp woods and meadows throughout.

Herb.: Taylor, Chisago lake; Sandberg, Sandy lake; Campbell, Ottertail Co.; Wheeler, Lyon, Echo lake; Lyon, Ft. Snelling reservation; Rosendahl, Spring Grove; MacMillan, Brand and Lyon, Grand Marais; MacMillan and Sheldon, Lake of the Woods; Wheeler, Rosendahl, Butters and Lyon, Lake Itasca.

The specimens cited above present a most perplexing array of forms. A further field-study and comparison with authentic specimens must, however, be made before they can be assigned to other than this species.

During the spring of the present year, gametophytes of this plant have been collected in considerable numbers by the writer, near Echo lake. In shape they resemble those of *Botrychium virginianum* but are only about one third their size. The reproductive organs are produced on the upper side. The primary root of the embryo sporophyte grows down through the tissue of the gametophyte instead of coming out on the upper side as in *B. virginianum*.

The root often protrudes an inch from the prothallium before the first leaf bursts through the calyptra. The life-history of the plant will be worked out as far as possible from the material obtainable.

Botrychium virginianum (L.) Swz. Schrad. Journ. Bot. 2: 111. 1800. Rattlesnake-fern.

Throughout the state.

Herb.: Many specimens.

The gametophytes of *B. virginianum* have been collected in two localities in this state. Lyon, Grand Marais, 1901; Lyon, Echo lake, 1903.

Family OSMUNDACEÆ.

Osmunda regalis L. Sp. Pl. 1065. 1753. Royal fern. Flowering fern.

Frequent throughout the northern half of the state. Low open woods.

Herb.: Numerous collections.

Osmunda claytoniana L. Sp. Pl. 1066. 1753. Interrupted fern.

Throughout the state. In moist shaded soil.

Herb.: Many specimens.

Osmunda cinnamomea L. Sp. Pl. 1066. 1753. Cinnamon fern.

Range about the same as that of the royal fern but occurring less frequently.

Herb.: Sandberg, Hennepin county; Aiton, Minneapolis; Ballard, Stony Brook and Upper Gull lake; Sheldon, Garrison and Mille Lacs reservation.

Family POLYPODIACEÆ.

Polypodium vulgare L. Sp. Pl. 1085. 1753. Common polypody.

Frequent throughout the state on rocks and rocky hillsides.

Herb.: Many specimens.

Adiantum pedatum L. Sp. Pl. 1095. 1753. Maiden-hair fern.

Common throughout the state in woods and shaded ravines.

Herb.: Collections from all parts of the state.

Pteridium aquilinum (L.) KUHN; Decken's Reisen **3**: 11. 1879. Brake. Bracken.

Pteris aquilina L. Sp. Pl. 1075. 1753.

Common throughout the state in open woods and brush-covered areas.

Herb.: Many specimens from scattered localities.

Cheilanthes Feei MOORE, Ind. Fil. 38. 1857. Slender lip-fern.

Cheilanthes gracilis (FÉE) METT. Abh. Senck. Nat. Gesell. **3**: (reprint 36). 1859.

Rare. Dry cliffs.

Herb.: Lyon 299, Houston county.

Cryptogramma stelleri (GMEL.) PRANTL; Engler's Bot. Jahr. **3**: 413. 1882. Slender cliff-brake.

Pellæa stelleri (GMEL.) WATT, Con. Fil. no. 2. 1869–70.

Infrequent or rare. Occurring usually on moist limestone ledges.

Herb.: Anderson, Featherstone; Leiberg, Minneopa Falls; Lyon, Houston county; Sandberg and Holzinger, Winona; Rosendahl, Spring Grove; Lyon, Hastings.

Pellæa atropurpurea (L.) LINK, Fil. Hort. Berol. 59. 1841. Purple-stemmed cliff-brake.

Locally common but localities infrequent. Seeming to prefer exposed limestone cliffs.

Herb.: Holzinger, Winona; Rosendahl, Lyon, Houston county; Sandberg, Cannon Falls; Leiberg, Blue Earth county; Sheldon, Taylors Falls; Lyon, Hastings.

Asplenium platyneuron (L.) OAKES; D. C. Eaton, Ferns N. A. **1**: 24. 1879. Ebony spleenwort.

Reported from Taylor's Falls by Upham but there are no specimens in the herbarium to verify the report.

Asplenium trichomanes (L.) Sp. Pl. 1080. 1753. Maidenhair spleenwort.

Reported by Upham as occurring at Taylor's Falls and Lake Pepin. Rare.

Herb.: Nelson, Vasa, Goodhue county.

Asplenium angustifolium MICHX. Fl. Bor. Am. **2**: 265. 1803. Narrow-leaved spleenwort.

Known to occur in but one locality.

Herb.: Lyon, Mayville, Houston county.

Asplenium acrostichoides SWZ. Schrad. Journ. Bot. **2**: 54. 1800. Silvery spleenwort.

Asplenium thelypteroides MICHX. Fl. Bor. Am. **2**: 265. 1803.

Infrequent in eastern portion of state.

Herb.: Sheldon, Mora; Lyon, Houston county.

Asplenium filix-fœmina (L.) BERNH. Schrad. Neues Journ. Bot. **1**: Part 2, 26. 1806. Lady-fern.

Common in woodlands throughout the state.

Herb.: A large number of specimens.

Camptosorus rhizophyllus (L.) LINK, Hort. Berol. **2**: 69. 1833. Walking-fern.

Infrequent. Occurring in widely separated localities on dry limestone rocks.

Herb.: Sandberg, Goodhue county; Rosendahl, Fillmore county; Lyon, Houston county; Lyon, Hastings.

Phegopteris phegopteris (L.) UNDERW.; Small, Bull. Torr. Club, **20**: 462. 1893. Long beech-fern.

Phegopteris polypodioides FÉE, Gen. Fil. 243. 1850–52.

Common in northern Minnesota in moist woods and on shaded banks.

Herb.: Sheldon, Waldo; Roberts, north shore of Lake Superior; Bailey, Basswood lake, Agate bay and Vermilion lake.

Phegopteris hexagonoptera (MICHX.) FÉE, Gen. Fil. 243. 1850–52. Broad beech-fern.

Upham reports this fern as occurring plentifully at Duluth and throughout the southern half of the state, but rare.

Herb.: Not represented by specimens.

Phegopteris dryopteris (L.) Fée, Gen. Fil. 243. 1850–52. Oak-fern.

Common in northern Minnesota in shaded places.

Herb.: Numerous collections.

Phegopteris robertiana (Hoffm.) A. Br. in Sched.; Milde Filic. Europ. et Atlant. 99. 1867.

Phegopteris calcarea Fée, Gen. Fil. 243. 1850–52.

Reported from Minnesota by D. C. Eaton, Ferns of North America 2: 277. 1880. There are no specimens in the herbarium.

Dryopteris noveboracensis (L.) A. Gray, Man. 630. 1848.

Found in eastern Minnesota according to Upham's report. There are no specimens in the herbarium.

Dryopteris thelypteris (L.) A. Gray, Man. 630. 1848. Marsh shield-fern.

Common in marshes throughout the state.

Herb.: Many specimens.

Dryopteris fragrans (L.) Schott, Gen. Fil. 1834. Fragrant shield-fern.

Frequent on rocks in northern Minnesota.

Herb.: Cheney, Partridge falls, Pigeon river; Bailey, Basswood lake; MacMillan and Sheldon, Lake of the Woods.

Dryopteris cristata (L.) A. Gray, Man. 631. 1848. Crested shield-fern.

Frequent in tamarack and spruce swamps.

Herb.: Aiton, Rice county; Arthur, Vermilion lake; Bailey, Mud river; Ballard, Chaska; Butters, Detroit; Sheldon, St. Croix Falls; Taylor, Center City.

Dryopteris goldieana (Hook.) A. Gray, Man. 634. 1848. Goldie's fern.

In southern Minnesota in rich woods. Quite rare.

Herb.: Sheldon, Leiberg, Blue Earth county; Lyon, Houston county.

Dryopteris filix-mas (L.) Schott. Gen. Fil. 1834. Male fern.

Occurring north of lake Superior according to Upham. This fern has probably been overlooked by collectors, being confused with other species.

Herb.: Sheldon, Minneapolis.

Dryopteris marginalis (L.) A. GRAY, Man. 632. 1848. Evergreen wood-fern.

Reported by Upham, but there are no specimens in the herbarium to verify the report.

Dryopteris spinulosa (RETZ) KUNTZE, Rev. Gen. Pl. 813. 1891. Spinulose wood-fern.

In woods throughout the state.

Herb.: A large collection.

Dryopteris spinulosa intermedia (MUHL.) UNDERW. Native Ferns, Ed. 4, 116. 1893.

With the species.

Herb.: Several specimens.

Dryopteris spinulosa dilatata (HOFFM.) UNDERW. Native Ferns, Ed. 4, 116. 1893.

Herb.: Holzinger, Grand Portage island.

Dryopteris boottii (TUCK.) UNDERW. Native Ferns, Ed. 4, 117. 1893.

Reported from this state by Upham.

Herb.: No specimens.

Polystichum lonchitis (L.) ROTH. Tentamen Fl. Germ. 3: 71. 1800. Holly fern.

Dryopteris lonchitis KUNTZE, Rev. Gen. Pl. 813. 1891.

Not previously reported from Minnesota. Rare.

Herb.: Nelson, Lake Superior.

Polystichum acrostichoides (MICHX.) SCHOTT. Gen. Fil. 2: no. 4. 1834. Christmas fern.

Dryopteris acrostichoides (MICHX.) KUNTZE, Rev. Gen. Pl. 812. 1891.

Reported from Minnesota by Upham.

Herb.: No specimens.

Filix bulbifera (L.) UNDERW. Native Ferns, Ed. 6, 119. 1900. Bulblet-fern.

Cystopteris bulbifera (L.) BERNH.; Schrad. Neues Journ. Bot. 1: Part 2, 26. 1806.

Damp shaded hillsides, preferring rocky slopes.

Herb.: Numerous collections.

Filix fragilis (L.) UNDERW. Native Ferns, Ed. 6, 119. 1900. Brittle fern.

Cystopteris fragilis (L.) BERNH.; Schrad. Neues Journ. Bot. 1: Part 2, 27. 1806.

Common throughout the state in moist shaded places.

Herb.: A large collection.

Onoclea sensibilis L. Sp. Pl. 1062. 1753. Sensitive fern.

Common in damp low woods and meadows throughout the state.

Herb.: Many specimens.

Matteuccia struthiopteris (L.) TODARO, Synops. Plantar. Acotyl. Vascul. in Sicilia sponte cresc. 30. 1866. Ostrich fern.

Onoclea struthiopteris (L.) HOFFM. Deutsch. Fl. **2**: 11. 1795.

Throughout the state in moist woods and thickets.

Herb.: Well represented by specimens.

Woodsia ilvensis (L.) R. BR. Trans. Linn. Soc. **11**: 173. 1812. Rusty woodsia.

Occurring quite commonly on rocks in northern Minnesota and infrequently in the central portion of the state.

Herb.: Taylor, St. Croix Falls, Taylors Falls; Sheldon, Taylors Falls, New Ulm; Bailey, Vermilion lake, Agate bay; Juni, Beaver bay; MacMillan and Sheldon, Lake of the Woods; Holzinger, Winona.

Woodsia glabella R. BR. App. Franklin's Journ. 754. 1823. Smooth woodsia.

Reported by Upham as occurring at Stillwater, but there are no specimens in the herbarium to verify the report.

Woodsia scopulina D. C. EATON, Can. Nat. **2**: 90. 1865. Rocky Mountain woodsia.

Only known to occur in the southern portion of the state. In dry situations.

Herb.: Wheeler, Luverne; Rosendahl, Spring Grove.

Woodsia oregana D. C. EATON, Can. Nat. **2**: 90. 1865. Oregon woodsia.

Found at Stillwater according to Upham. Rare.

Herb.: Lyon, Jefferson, Houston county.

Woodsia obtusa (SPRENG.) TORR. Cat. Pl. in Geol. Rep. N. Y. 195. 1840. Blunt-lobed woodsia.

On rocks, infrequent or rare.

Herb.: Rosendahl, Spring Grove; Nelson, Vasa.

Dennstædtia punctilobula (MICHX.) MOORE, Index Fil. **97**: 307. 1857–62. Hay-scented fern.

Dicksonia punctilobula (MICHX.) A. GRAY, Man. 628. 1848.

Reported from Minnesota by Upham. Its occurrence however must be considered doubtful.

Herb.: Not represented.

Family SALVINIACEÆ.

Salvinia natans (L.) HOFFM. Deutsch. Fl. 2: 1. 1795. Salvinia.

Rare.

Herb.: Sheldon, Cuzner, Minneapolis.

Azolla caroliniana WILLD. Sp. Pl. 5: 541. 1810. Carolina azolla.

Infrequent. In the sloughs of the Mississippi river below Lake Pepin.

Herb.: Holzinger, Winona; Lyon, Jefferson, Houston county.

XXI. AN ADDITION TO THE KNOWLEDGE OF THE FLORA OF SOUTHEASTERN MINNESOTA.

C. O. ROSENDAHL.

Further work of the Minnesota Botanical Survey carried on in the southeastern part of the state during the month of June, 1902, resulted in the collection of about 100 species additional to those previously reported from the region by Mr. W. A. Wheeler * and also extended several plant ranges.

The territory covered is limited to the southwestern part of Houston county and the eastern part of Fillmore county as far north as the Root river.

Most of the collecting was done however in Spring Grove and Blackhammer townships, and a single excursion only was made into the part of Fillmore county above mentioned.

The topography of this part of Houston county differs considerably from the remaining region north and east, the largest part of which is much the same as that described in Mr. Wheeler's report.

Spring Grove, the corner township, is the highest part of the county, its elevation ranging from 1,050 feet in the northwest corner to over 1,300 feet on section 16, situated near the center.

There are numerous valleys throughout the southern and southeastern part of the township and a few in the northwestern part. None of these is deep and nearly all of them have gradually sloping sides to within 30–60 feet from the top of the ridges where the incline is more abrupt.

These valleys, and slopes also, are generally cultivated and the valleys possess the richest soil of the region.

They nearly all trend north and northwest and south and southeast from both sides of a high central ridge running from the southwestern to the northeastern part of the township.

* A contribution to the knowledge of the flora of southeastern Minnesota. Minn. Bot. Studies, 2: 353. 1900.

This main ridge, capped by Trenton limestone and underlaid with St. Peter sandstone, represents in this region the farthest eastward extension of the high rolling prairie of northeastern Iowa. Typical prairie plants like *Psoralea argophylla*, *Eryngium yuccæfolium*, *Mesadenia tuberosa*, *Parthenium integrifolium* and others find a home here, in fact prairie vegetation in general is met with upon all the principal ridges.

The sides of the bluffs and the upper narrowing valleys are generally wooded, especially in the eastern portion where even the ridges either have been or still remain forested. Southwestward the timber disappears.

Blackhammer township, adjoining Spring Grove on the north, is considerably lower, and is cut through in the western portion by Riceford creek, flowing north, and in the eastern portion by Beaver creek, also north bound.

The intervening region from north to south has an elevation of about 1,100 feet and is essentially a rolling prairie.

The bluffs along the two creeks are high and steep. As a rule the slopes are heavily wooded except those facing south.

The region of Fillmore county explored is traversed by the South fork of Root river, and by Root river itself. The topography and vegetation are essentially like that described for southeastern Houston county in Mr. Wheeler's report.

That part of Spring Grove township lying to the south of, and westwardly merging into the high central ridge described, proved the most interesting and best collecting ground of the territory covered.

It is interesting because of the fact that it borders immediately upon a true prairie region and yet harbors such species as occur typically in the northern part of the state.

Among the most important of these should be mentioned:

Botrychium obliquum,	*Sabbaldiopsis tridentata*,
Woodsia scopulina,	*Viola leconteana*,
Woodsia obtusa,	*Cornus canadensis*,
Juniperus sabina,	*Pyrola secunda*,
Carex albursina,	*Chimaphila umbellata*,
Leptorchis liliifolia,	*Arctostaphylos uva-ursi*.

It is worth noting that these, with the exception of *Woodsia scopulina*, *Woodsia obtusa*, *Juniperus sabina* and *Carex albursina*, were found in one place.

They were collected on the top and north slope of a ridge running east and west, less than half a mile long, and which rolls off southwestwardly into the prairie.

Pyrola secunda and *Chimaphila umbellata* occur infrequently on some of the wooded ridges. The other plants enumerated, with the exceptions noted, were found only at this place.

Sibbaldiopsis tridentata, growing on exposed rocks at the northwest extremity of the ridge, is of very infrequent occurrence in the state outside the Lake Superior region.

A few of the species collected are of particular interest, as no previous authentic collection of them has been reported from the state before. They are:

Homalocenchrus lenticularis,
Melica diffusa,
Poa wolfii,
Anychia canadensis,
Viola indivisa,
Viola mesochora,
Viola achlydophylla.

The following have been reported, but are not represented by any previous collection from Minnesota in the University Herbarium:

Carex cephalophora,
Carex muhlenbergii,
Parthenium integrifolium.

Catalogue of Additional Species Collected.

The following catalogue of plants is in the nature of an addition to Mr. Wheeler's report for the region, and out of the entire collection made cites only such species as were not given in his report:

All the collections with one exception were made by the writer and in the region specified.

Prof. E. L. Greene, of the Catholic University of America, determined the violets.

Mr. C. F. Wheeler, of the U. S. Dept. of Agric., determined two species of *Carex*.

Mr. H. L. Lyon, of the University of Minnesota, determined the Pteridophytes, and Mr. W. A. Wheeler, of the University of Minnesota, School of Agriculture, determined all the grasses.

The other determinations were made by the collector. The specimens have been inserted in the University Herbarium.

PTERIDOPHYTA.

OPHIOGLOSSACEÆ.

Botrychium obliquum MUHL.; Willd. Sp. Pl. 5: 63. 1810.
R. 517, 660. Spring Grove.
Infrequent on wooded ridges.

POLYPODIACEÆ.

Woodsia scopulina D. C. EATON, Can. Nat. 2: 90. 1865.
R. 296. Spring Grove.
The only previous collections reported from the state are from Duluth and Taylors Falls by Miss Cathcart, and from Blue Earth county by Mr. Gedge. The only previous collection in the University Herbarium is from Rock county by Mr. W. A. Wheeler.

Woodsia obtusa (SPRENG.) TORR, Cat. Pl. in Geol. Rep. N. Y. 195. 1840.
R. 343. Spring Grove.
Infrequent or rare southeast. Occurs in crevices of the St. Peter sandstone. Reported by Upham as occurring throughout the state. The only previous collection in the University Herbarium is from Goodhue county by N. L. T. Nelson.

METASPERMÆ.

GRAMINEÆ.

Panicum linearifolium SCRIBN. in Br. & Br. Ill. Fl. App. 3: 500. 1898.
R. 259. Spring Grove.

Panicum leibergii (VASEY) SCRIBN.; Vasey, U. S. Dept. Agric., Div. Bot. Bull. 8: 32. 1899.
R. 504, 538, 619, 621. Spring Grove.

Homalocenchrus lenticularis (MICHX.) SCRIBN. Mem. Torr. Club, 5: 33. 1894.
Lyon, 713, Aug., 1900. Jefferson, Houston county.
Not previously reported from Minnesota.

Phalaris arundinacea L. Sp. Pl. 54. 1753.
R. 648, 665. Spring Grove.

Stipa spartea TRIN. Mem. Acad. St. Petersb. (VI) 1: 82. 1831.

R. 314. Spring Grove.

Agrostis hyemalis (WALT.) B.S.P. Prel. Cat. N. Y. 68. 1888.

R. 297. Spring Grove.

Calamagrostis canadensis (MICHX.) BEAUV. Agrost. 157. 1812.

R. 521. Spring Grove.

Danthonia spicata (L.) BEAUV., R. & S. Syst. 2: 690. 1817.

R. 514. Spring Grove.

Eragrostis pectinacea (MICHX.) STEUD. Syn. Pl. Gram. 272. 1885.

R. 258. Spring Grove.

Eatonia obtusata (MICHX.) A. GRAY, Man. Ed. 2, 558. 1836.

R. 533, 612. Spring Grove.

Eatonia pennsylvanica (DC.) A. GRAY, Man. Ed. 2, 558. 1856.

R. 534. Spring Grove. R. 584. Whalan, Fillmore county.

Melica diffusa PURSH, Fl. Am. Sept. 77. 1814.

R. 592. Whalan, Fillmore county.

Rare, along the Root river. No previous collection reported from Minnesota.

Poa flava L. Sp. Pl. 68. 1753.

R. 611, 649. Spring Grove.

Poa wolfii SCRIBN. Bull. Torr. Club, 21: 228. 1894.

R. 285. Spring Grove.

Infrequent or rare on dry, wooded hillsides. No previous collection reported from Minnesota.

Poa compressa L. Sp. Pl. 69. 1753.

R. 364. Spring Grove.

Panicularia nervata (WILLD.) KUNTZE, Rev. Gen. Pl. 783. 1891.

R. 459, 494, 527, 634. Spring Grove.

Festuca octoflora WALT. Fl. Car. 81. 1788.

R. 298, 689. Spring Grove.

Festuca elatior L. Sp. Pl. 75. 1753.

R. 495, 688. Spring Grove.

Festuca nutans WILLD. Enum. 1: 116. 1809.

R. 286, 557. Spring Grove.

Bromus purgans L. Sp. Pl. 176. 1753.

R. 434, 574. Spring Grove.

Agropyron pseudorepens SCRIBN. & SM. U. S. Dept. Agric. Div. Agrost. Bull. 4, 34. 1897.

R. 628. Bratsberg, Fillmore county.

Agropyron repens (L.) BEAUV. Agrost. 146. 1812.

R. 446, 447. Spring Grove.

Hystrix hystrix (L.) MILLSP. Fl. W. Va. 474. 1892.

R. 596, 657, 704. Spring Grove.

CYPERACEÆ.

Carex haydeni DEWEY, Am. Journ. (II) **18**: 103. 1854.

R. 405. Spring Grove.

Carex grisea WAHL. Kongl. Vet. Acad. Handl. (II) **24**: 154. 1803.

R. 469, 561. Spring Grove.

Carex granularis MUHL.; Willd. Sp. Pl. **4**: 279. 1805.

R. 554. Spring Grove.

Carex laxiflora blanda (DEWEY) BOOTT, Ill. 37. 1858.

R. 407. Spring Grove.

Carex albursina SHELD. Bull. Torr. Club, **20**: 284. 1893.

R. 597. Whalan, Fillmore county.

Infrequent on densely wooded bluffs along the Root river.

The only previous collections from the state in the University Herbarium are from White Bear lake and Waseca county. by E. P. Sheldon.

Carex pennsylvanica LAM. Encycl. **3**: 388. 1789.

R. 254. Spring Grove.

Carex gravida BAILEY, Mem. Torr. Club, **1**: 5. 1889.

R. 603. Whalan, Fillmore county.

Carex sparganioides MUHL.; Willd. Sp. Pl. **4**: 237. 1805.

R. 246. Spring Grove.

Carex cephaloidea DEWEY, Rep. Pl. Mass. 262. 1840.

R. 433, 457, 507. Spring Grove.

Carex cephalophora MUHL.; Willd. Sp. Pl. **4**: 220. 1805.

R. 227. Spring Grove.

Reported by Upham as frequent in the southern part of the state.

No previous collection from the state in the University Herbarium.

Carex muhlenbergii SCHK., Reidgr. Nachtr. *12. f. 178.* 1806.

R. 547. Spring Grove.

Rare southward according to Upham.

Reported from Chaska, Carver county, by Mr. Juni.

No previous collection from the state in the University Herbarium.

Carex scoparia Schk. Reidgr. Nachtr. *20. f. 175.* 1806.
R. 406. Spring Grove.

Carex straminea mirabilis (Dewey) Tuckerm. Enum. Meth. 18. 1843.
R. 508. Spring Grove.

Carex festucacea Willd. Sp. Pl. **4**: 242. 1805.
R. 428. Spring Grove.

Carex bicknellii Britton, Br. & Br. Ill. Fl. **1**: 360. 1896.
R. 264. Spring Grove.

Frequent on sandy hillsides.

The only previous collection from the state is from Blue Earth county, by W. D. Frost.

JUNCACEÆ.

Juncoides campestre (L.) Kuntze, Rev. Gen. Pl. 722. 1891.
R. 234. Spring Grove.

LILIACEÆ.

Allium tricoccum Ait, Hort. Kew. **1**: 428. 1789.
R. 672. Spring Grove.

Allium canadensis L. Sp. Pl. 1195. 1753.
R. 667, 305. Spring Grove.

SMILACEÆ.

Smilax ecirrhata (Engelm.) S. Wats. in A. Gray, Man. Ed. 6, 520. 1890.
R. 449. Spring Grove.

IRIDACEÆ.

Sisyrinchium campestre Bicknell, Bull. Torr. Club, **26**: 341. 1899.
R. 241, 242, 265. Spring Grove.

ORCHIDACEÆ.

Lysias hookeriana (A. Gray) Rydb. Mem. N. Y. Bot. Gard. Vol. I. 103. 1900.
R. 301. Spring Grove.

Corallorhiza corallorhiza (L.) KARST. Deutsch. Fl. 448. 1880–83.
R. 1158. Spring Grove.

POLYGONACEÆ.

Rumex altissimus WOOD, Class-book, 447. 1853.
R. 392. Spring Grove.

Polygonum lapathifolium L. Sp. Pl. 360. 1753.
R. 650. Spring Grove.

Polygonum persicaria L. Sp. Pl. 361. 1753.
R. 647. Spring Grove.

Polygonum aviculare L. Sp. Pl. 362. 1753.
R. 531. Spring Grove.

CHENOPODIACEÆ.

Chenopodium album L. Sp. Pl. 219. 1753.
R. 642, 651. Spring Grove.

Chenopodium leptophyllum (MOQ.) NUTT.; Moq. in DC. Prodr. **13**: Part 2, 71. 1849.
R. 685. Spring Grove.

Chenopodium hybridum L. Sp. Pl. 219. 1753.
R. 1159. Spring Grove.

CARYOPHYLLACEÆ.

Silene noctiflora L. Sp. Pl. 419. 1753.
R. 558. Spring Grove.

Cerastium vulgatum L. Sp. Pl. Ed. 2, 627. 1762.
R. 230. Spring Grove.

Moehringia lateriflora (L.) FENZL. Verb. Alsin. table, p. 18. 1833.
R. 229, 232. Spring Grove.

Anychia canadensis (L.) B.S.P. Prel. Cat. N. Y. 1888.
R. 1160. Spring Grove.
Infrequent on wooded hillsides.
Not previously reported from Minnesota.

RANUNCULACEÆ.

Ranunculus ovalis RAF. Proc. Dec. 36. 1814.
R. 356. Spring Grove.

Ranunculus recurvatus POIR in Lam. Encycl. **6**: 125. 1804.
R. 358. Spring Grove.

Ranunculus hispidus Michx. Fl. Bor. Am. 1: 321. 1803.
R. 284. Spring Grove.

CRUCIFERÆ.

Iodanthus pinnatifidus (Michx.) Steud. Nomencl. Ed, 2, 812. 1841.
R. 590. Whalan, Fillmore Co.
Infrequent along the Root River at this place.
The only previous collection from the state is from Red Wing, by Sandberg.

GROSSULARIACEÆ.

Ribes missouriensis Nutt.; Torr. & Gray, Fl. N. Am. 1: 548. 1838–40.
R. 411. Spring Grove.

ROSACEÆ.

Rubus strigosus Michx. Fl. Bor. Am. 1: 297. 1803.
R. 376. Spring Grove.

Sibbaldiopsis tridentata (Soland.) Rydb. N. Am. Potent. 187. 1898.
R. 511. Spring Grove.
Rare and local, on dry sandstone ledge. This appears to be about the most southern point of occurrence in the upper Mississippi Valley.

Fragaria americana (Porter) Britton, Bull. Torr. Club, 19: 222. 1892.
R. 472, 383, 398. Spring Grove.

Sieversia ciliata (Pursh) Rydb. Mem. N. Y. Bot. Garden, Vol. 1, 222. 1900.
R. 251. Spring Grove.

POMACEÆ.

Prunus pumila L. Mant. Pl. 75. 1767.
R. 309. Spring Grove.
Infrequent on dry stony hillsides.

Prunus pennsylvanica L. f. Suppl. 252. 1781.
R. 654. Spring Grove.

PAPILIONACEÆ.

Psoralea argophylla Pursh, Fl. Am. Sept. 475. 1814.
R. 571. Spring Grove.

Astragalus crassicarpus NUTT. Fraser's Cat. 1813.
R. 331. Spring Grove.

Lathyrus palustris L. Sp. Pl. 733. 1753.
R. 613. Whalan, Fillmore county.

RHAMNACEÆ.

Ceanothus ovatus pubescens T. & G.; S. Wats. Bibl. Index, 1: 166. 1878.
R. 252. Spring Grove.

VIOLACEÆ.

Viola indivisa GREENE, ined.
R. 355. Spring Grove.

Viola cuspidata GREENE, Pitt. 3: 314. 1898.
R. 238, 352. Spring Grove.

Viola mesochora GREENE, ined.
R. 386. Spring Grove.

Viola leconteana DON. Gen. Syst. 1, 324.
R. 509. Spring Grove.
Infrequent, in moist shady woods.

There are various collections in the University Herbarium, mostly from the northern part of the state, which are determined as variety *amœna* of *Viola blanda* that should be included under the above-named species.

Viola achlydophylla GREENE, Pitt. 5: 87. 1902.
R. 467. Spring Grove.
Frequent, in moist shady woods.
Not previously reported from Minnesota.

ONAGRACEÆ.

Meriolix serrulata (NUTT.) WALP. Rep. 2: 79. 1843.
R. 568. Spring Grove.
Infrequent, on exposed hillsides.

UMBELLIFERÆ.

Eryngium yuccæfolium MICHX. Fl. Bor. Am. 1: 164. 1803.
R. 678. Spring Grove.
Occurs infrequently on some of the high, dry ridges of the region.

CORNACEÆ.

Cornus canadensis L. Sp. Pl. 117. 1753.

R. 510. Spring Grove.

Rare and local, the most southern collection in the state previously reported is from Wabasha county by J. M. Holzinger.

PYROLACEÆ.

Pyrola secunda L. Sp. Pl. 396. 1753.

R. 518, 564. Spring Grove.

Previously reported as far south as Blue Earth county.

Infrequent, in shady woods.

Chimaphila umbellata (L.) NUTT. Gen. 1: 274. 1818.

R. 380, 520, 645. Spring Grove.

Rare and local, on wooded ridges.

Monotropa uniflora L. Sp. Pl. 387. 1753.

R. 1161. Spring Grove.

Infrequent, throughout the wooded region.

GENTIANACEÆ.

Gentiana puberula MICHX. Fl. Bor. Am. 1: 176. 1803.

R. 1162. Spring Grove.

ASCLEPIADACEÆ.

Asclepias ovalifolia DEC. in DC. Prodr. 8: 567. 1844.

R. 460. Spring Grove.

Infrequent, on dry, sandy hillsides.

Acerates viridiflora ivesii BRITTON, Mem. Torr. Club, 5: 265. 1894.

R. 681, 655. Spring Grove.

Acerates lanuginosa (NUTT.) DEC. in DC. Prodr. 8: 523. 1844.

R. 304, 442. Spring Grove.

CONVOLVULACEÆ.

Convolvulus repens L. Sp. Pl. 153. 1753.

R. 476. Spring Grove.

BORAGINACEÆ.

Lithospermum latifolium MICHX. Fl. Bor. Am. 1: 13. 1803.

R. 408. Spring Grove.

SOLANACEÆ.

Physalis virginiana intermedia RYDB. Mem. Torr. Club, 4: 345. 1896.

R. 310. Spring Grove.

SCROPHULARIACEÆ.

Scrophularia leporella Bicknell, Bull. Torr. Club, **23**: 317. 1896.

R. 300. Spring Grove.

Previous collections from this region reported as *Scrophularia marylandica* L. should be *Scrophularia leporella* Bicknell.

RUBIACEÆ.

Galium concinnum T. & G. Fl. N. Am. **2**: 23. 1841.

R. 529. Spring Grove.

Abundant, in woods throughout.

CAPRIFOLIACEÆ.

Viburnum pubescens (Ait.) Pursh, Fl. Am. Sept. 202. 1814.

R. 226. Spring Grove.

All Minnesota collections reported as *Viburnum dentatum* L. should be *Viburnum pubescens* (Ait.) Pursh.

Symphoricarpos occidentalis Hook. Fl. Bor. Am. **1**: 285. 1823.

R. 409. Spring Grove.

Frequent, along Riceford creek.

CICHORIACÆ.

Lactuca canadensis L. Sp. Pl. 796. 1753.

R. 537. Spring Grove.

Nothocalais cuspidata (Pursh) Greene, Bull. Acad. (II.) **2**: 55. 1886.

R. 319. Spring Grove.

Common, on stony ridges.

COMPOSITÆ.

Kuhnia glutinosa Ell. Bot. S. C. & G. **2**: 292. 1821–24.

R. 1163. Spring Grove.

Previous collections from this region reported as *Kuhnia eupatorioides* L. should be *Kuhnia glutinosa* Ell.

Erigeron philadelphicus L. Sp. Pl. 863. 1753.

R. 441, 447. Spring Grove.

Parthenium integrifolium L. Sp. Pl. 988. 1753.

R. 483. Spring Grove.

Reported by Lapham from the southern part of the state. No previous collection from Minnesota in the University Herbarium.

Occurs occasionally in the valleys but is most frequent on the dry elevated ridges.

Mesadenia tuberosa (NUTT.) BRITTON; Br. & Br. Ill. Fl. **3**: 474. 1898.

R. 704. Spring Grove.

Senecio balsamitæ MUHL.; Willd. Sp. Pl. 1999. 1804.

R. 268. Spring Grove.

R. 582. Whalan, Fillmore county.

XXII. A NEW SPECIES OF RAZOUMOFSKYA.

C. O. Rosendahl.

While engaged in the work of collecting the flowering plants and ferns of the west coast of Vancouver island during the summers of 1901 and 1902 excellent opportunity was given to observe the mistletoe which grows in great abundance upon the hemlock of that region.

The fact is perhaps generally known that this parasite causes peculiar fasciations, the so-called *Hexenbesen*, of the stem and branches of *Tsuga heterophylla* and attention is called to this in a recent publication of the U. S. Department of Agriculture.*

In this paper the parasite is designated as *Arceuthobium occidentale* Engelm. (*Razoumofskya occidentalis* (Engelm.) Kuntze), and it has been generally classed with that plant or with its variety *abietinum* Engelm.

Nearly all the specimens of *Razoumofskya occidentalis* (Engelm.) Kuntze, in the Herbarium of the University of Minnesota, have been collected on various species of *Pinus*, and Engelmann in the description of the species states that it occurs "on various conifers of the coast ranges and Sierra Nevada," citing *Pinus insignis*, *P. sabiniana* and *P. ponderosa*. The variety is given as occurring on *Abies grandis*.

Examination and comparison of specimens show that the plant found on the hemlock differs from *Razoumofskya occidentalis*, [redacted] growing mostly on pines, in being more slender, more loosely branched and in having the staminate and pistillate plants of about equal size. Not infrequently the staminate plant is the larger (Plate XXVII, fig. 5), which is the reverse of the condition met with in *R. occidentalis*. The staminate spikes are more slender, less densely flowered, and generally longer than those of the above-mentioned form.

* Allen, Edward T. The Western Hemlock, Bureau of Forestry, U. S. Dept. of Agric., Bull. 33. 1902.

It approaches more closely the variety *abietina*, and because of the fact that only fragmentary material of the latter is at hand for comparison, it is more difficult to show the essential differences, except in so far as those already pointed out for the species include those for the variety also.

From the material examined it is clear that the plant found on the hemlock has the calyx lobes more ovate in shape, and the fruit possesses a slightly shorter and thicker beak than in var. *abietina*.

With sufficient authentic material for comparison its affinities could perhaps be more definitely established.

It does not seem consistent to refer this plant to the variety when it is borne in mind that as far as observations go it is found exclusively on *Tsuga heterophylla* in a forest where abound such species as *Abies grandis*, the tree upon which the variety was first collected, *Abies amabilis*, *Pinus monticola*, *Pinus contorta* and various other conifers.

The hemlock is found almost everywhere on the west coast mixed with the trees mentioned above, but in no case whatever was the parasite found on any other tree than *Tsuga heterophylla* Sarg.

There seems sufficient reason for giving the plant specific rank and the name *Razoumofskya tsugensis* is proposed.

The type specimen is deposited in the herbarium of the University of Minnesota.

Razoumofskya tsugensis sp. nov.

Stems slender, paniculately branched; terminal branches of the staminate plants often apparently dichotomous: stem 1.5 mm. in diameter at the base: staminate plants 3–11 cm. high, brownish-yellow in color: flowers 1–13, sessile in the axils of the connate leaves of the branches, forming spicate inflorescences 4–24 mm. long: internodes of the flowering branches 2.5–3.5 mm. long: calyx 4-parted; lobes ovate, acute, thick: anthers sessile and attached about the middle of the calyx lobes: buds of the lateral flowers slightly flattened dorsi-ventrally, the terminal ones globose: expanded flower 3.5–4 mm. in diameter.

Pistillate plants 4–12 cm. high: generally darker in color than the staminate: flowers borne as in the staminate plants: branches flower-bearing for the last 1–6 nodes: internodes 3.5–

5 mm. long: flowers nearly sessile, partly enclosed by the connate leaves: fruit 4–5 mm. long, 2.5–3 mm. in diameter, obovate, short conic-beaked, slightly compressed dorsi-ventrally, at length becoming shortly stalked and reflexed.

Explanation of Plates.

Plate XXVII.

The figures are from photographs made by C. J. Hibbard and are a little less than natural size.

1. Pistillate plant in fruiting stage.
2. Pistillate plant attached to its host, a younger stage than fig. 1.
3–4. Staminate plants, medium size.
5. Large staminate plants, attached to their host.

Plate XXVIII.

1. Large pistillate plant in fruiting stage, slightly enlarged.
2. Two pistillate flowers, advanced stage, $\times 5$.
3. Single pistillate flower, $\times 5$.
4. Part of fruiting branch with nearly mature fruit in position, $\times 5$.
5. Fruit removed from plant, $\times 5$.
6. Medium sized staminate plant, slightly enlarged.
7. End of staminate spike, flowers in bud, $\times 5$.
8. Terminal staminate flower expanded, $\times 5$.
9. Terminal staminate flower, viewed from above, showing the circular stamens, $\times 6$.

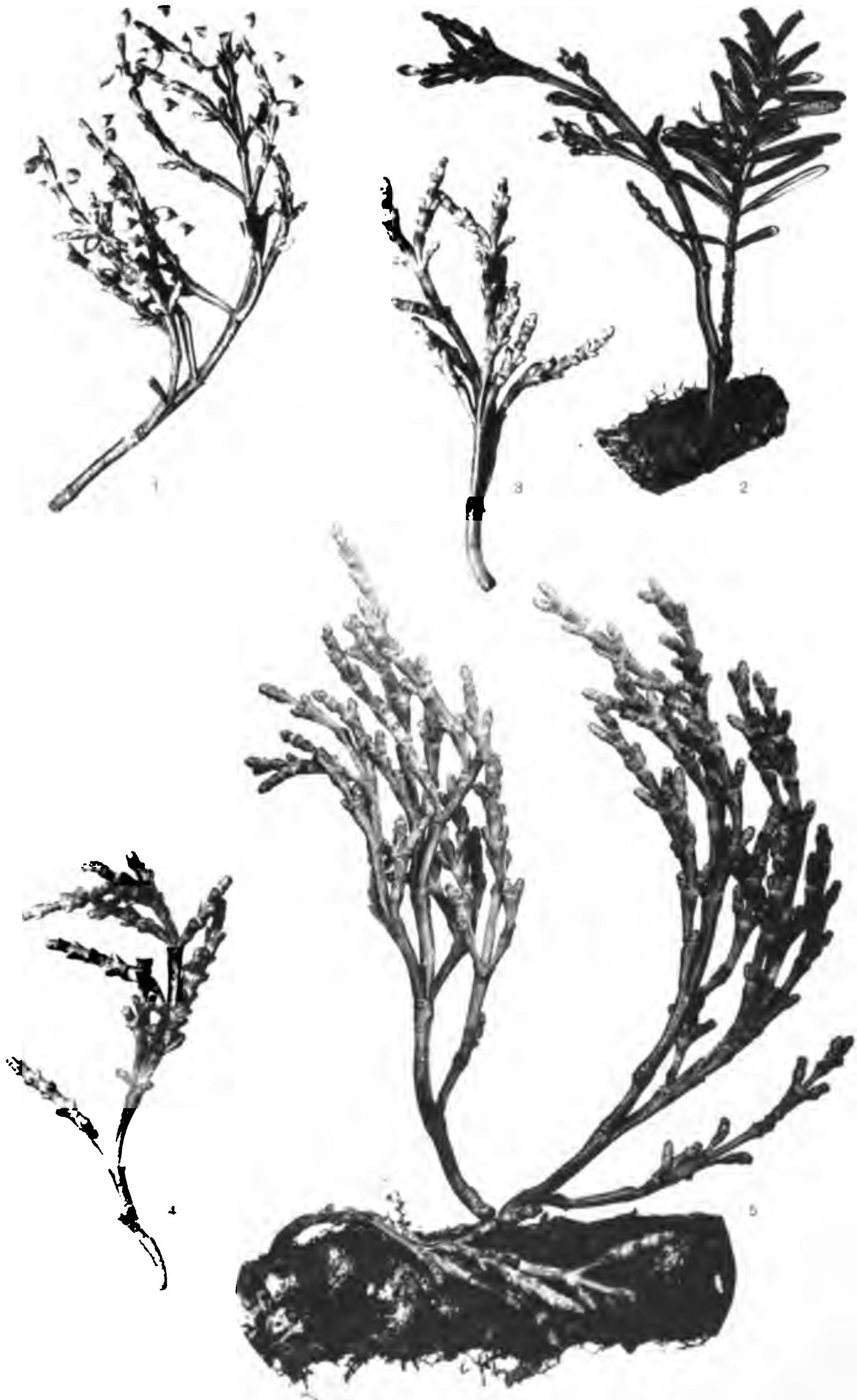


PLATE XXVII.

HELIOTYPE CO., BOSTON.

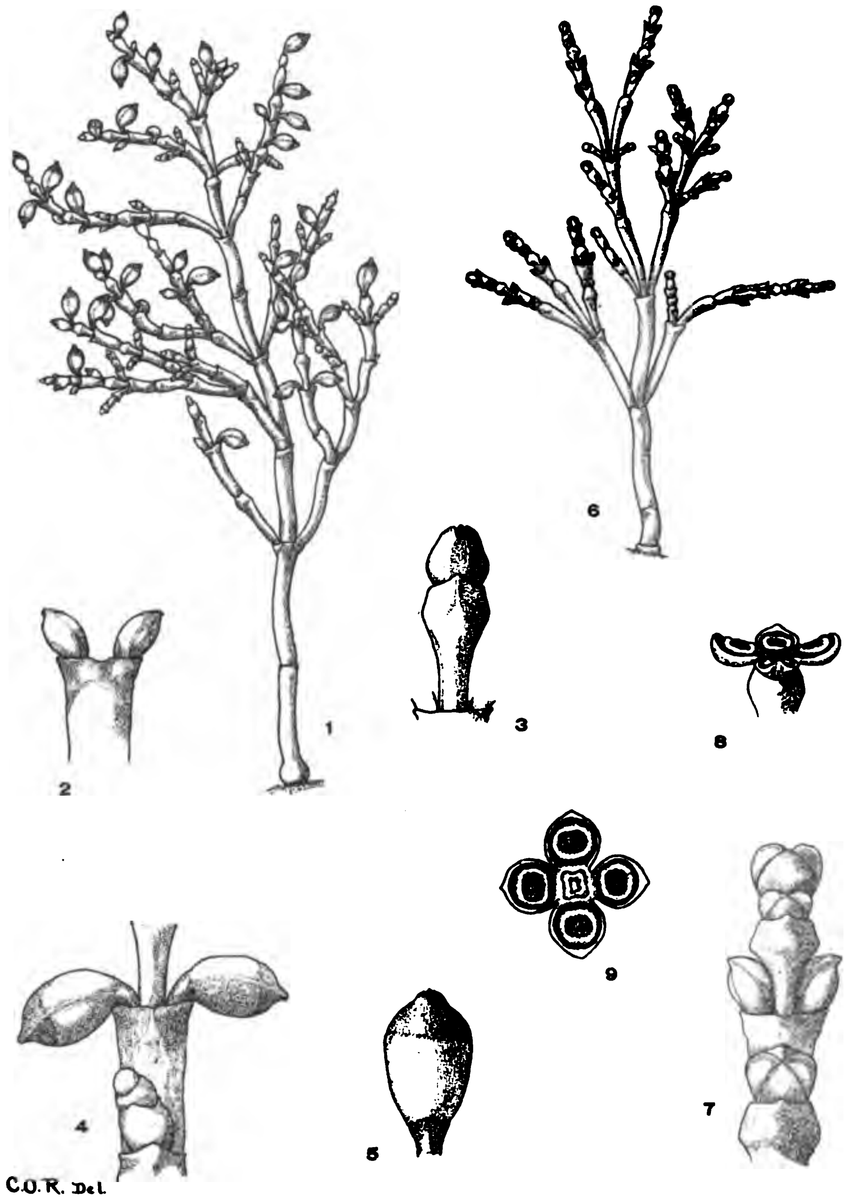


PLATE XXVIII.

HELIOTYPE CO., BOSTON.

Geological and Natural History Survey of Minnesota.
Conway MacMillan, *State Botanist*

Minnesota Botanical Studies

Contents

Third Series

Part III - - *October 18, 1904*

MINNEAPOLIS, MINN.
1904

XXIII. THE EMBRYOGENY OF GINKGO.

HAROLD L. LYON.

INTRODUCTION.

The account published by Coulter and Chamberlain in 1901 is the most recent work on the embryogeny of *Ginkgo* and may be taken as a summation of our knowledge on the subject up to the present time. They wrote as follows, "Although the embryo of *Ginkgo* is exceptional among Gymnosperms, and of great interest, the details of its development are not sufficiently known. We have been able to secure almost a complete series showing the general outlines of the development, which merely confirms the facts already published. Germination of the oöspore begins, as is usual, among Gymnosperms, with repeated nuclear divisions. These nuclei, however, instead of organizing a parietal tissue as in the Cycads, or a basal group as in the Conifers, proceed to fill the whole cavity of the enlarging oöspore with free nuclei, which is followed by the organization of a compact tissue. In a certain sense this structure would seem to represent the proembryo of Cycads, but it really represents the whole product of the oöspore, in which proembryo, suspensor, and embryo proper are not differentiated. The complete filling of the spore with tissue, and the lack of early differentiation into the great embryonic regions, would suggest a habit more primitive than in either Cycads or Conifers. At the same time, it may be merely a derived character. In any event, the tissue near the base of the spore, which in the other groups develops both suspensor and embryo, shows far greater vigor than the remaining tissue. In the organization of the embryo the whole mass of tissue is involved, and in the absence of a suspensor the embryo invades the endosperm by direct growth.

The two cotyledons are differentiated early in October, and are quite unequal in length. The larger one is two lobed, while the shorter one is cleft halfway down, thus early indicating the bilobed character of the leaf. The two cotyledons are also united at the apex, but the epidermal layers of the two are dis-

tinct where they are in contact. The plumule is very conspicuous between the elongated cotyledons, three or more leaves appearing just behind the stem apex."

In 1872 Strasburger published the first paper dealing with the embryogeny of *Ginkgo*. He determined the general course of events in the formation of the spherical embryo but insufficient material prevented the working out of details. Hirase ('95) studied fecundation and the origin of the spherical embryo. He found that there were eight simultaneous nuclear divisions in the oösperm preceding free-cell-formation. More recently Ikeno (1901) has made a very careful study of the process of fecundation.

The embryo of the seed has been frequently described, but little however seems to be known of its histology. Endlicher ('47) was the first to mention the occurrence of two or more embryos in one seed and recently Cook (1902, 1903) has called attention to polyembryony in *Ginkgo*. Miss Wigglesworth (1903) notes the presence of stomata on the cotyledons. LeMaout and Descaisne ('76) and Masters ('91) figure seedlings of *Ginkgo*. Van Tieghem ('70, '87) and Van Tieghem and Douliot ('88) record observations on the anatomy of the root system. Worsdell ('97) describes the vascular bundle and transfusion tissue of the cotyledon, and Seward and Gowan (1900) contribute some further observations on the anatomy of the seedling.

The remarkable ciliated spermatozoids of *Ginkgo* have received such critical attention from Japanese botanists[1] that no observations on these need be offered here. With the corroborative evidence from the cycads[2] our knowledge of the occurrence and development of ciliated spermatozoids in these Gymnosperms may be considered well established. In the present paper the subjects of oögenesis, spermatogenesis and fecundation will be avoided, the recorded observations dealing solely with the embryogeny. It is purposed to take up and continue the subject where Strasburger left it some thirty years ago.

Material.

The investigations, which are recorded in the following pages, were begun in 1901 on material received from the Botanical

[1] Hirase ('96, '97, '98), Fujii ('98, '99), Miyake ('98, 1902).

[2] Ikeno ('96, '97), Ikeno and Hirase ('97), Webber ('97[1], '97[2], 1901), Lang (1900).

Gardens of the Imperial University of Tokyo through the kindness of Mr. K. Yendo. Later large quantities of excellent material were obtained from the Missouri Botanical Garden, and it is principally from this material that embryological data have been obtained. The writer wishes to express his sincere thanks to Dr. William Trelease who has done every thing possible to facilitate the work. Some valuable preparations have also been obtained from a small number of seeds purchased from Thorburn & Co., seed dealers of New York. The location of the trees which bore these seeds was not determined. The material sent from Japan by Mr. Yendo, amounted to several quarts of seeds containing nearly mature embryos. The embryos were removed from a large number for examination, those shown in Plate XXXV. being some of the number, while many of the seedlings studied were grown from these seeds. Under the directions of Dr. Trelease, cuttings bearing megasporangia were sent from the Missouri Botanical Garden at intervals of a few days throughout an entire season. After the cut ends of the branches had been sealed over with paraffin, they were packed in moist sphagnum, wrapped first with oiled, then with heavy paper and sent by parcel-post. These excellent precautions brought the material to this laboratory in a perfectly fresh condition. Upon arrival it was immediately placed in the various fixing fluids.

RESEARCH.

A. The Embryo.

1. *The Protocorm.* — At the completion of free-division the nuclei are quite evenly distributed through the cytoplasm of the oösperm (*fig. 1*), and when the formation of walls between these nuclei is first completed the resulting cells show no marked dissimilarity in shape, size or contents (*fig. 2*). The cells, in the upper two thirds or more of this spherical protocorm, divide only a few times or not at all. Their protoplasmic contents become thin and watery, and they take no part in the organization of the metacormal bud or blastema. The cells in the lower portion of the protocorm divide repeatedly, the relative activity increasing towards the base so that in this region there is organized a small-celled tissue (*figs. 3, 4*). This basal tissue passes over directly into the small-celled meristem of the blastema. With the advance of the metacorm into the body of the gametophyte, the protocormal tissue is forced back through the neck

of the archegonium until it comes in contact with the firm nucellar tissue (*figs. 4–9*). Many of its cells are often crushed by this backward pressure, but in the mature embryo of the seed the protocormal region is still evident (*figs. 11, 34, 36*).

2. *The Blastema.* — The blastema arises directly from the small-celled, basal tissue of the protocorm, and invades the gametophyte as a broad, blunt cylinder (*figs. 4, 5, 6, 8*). The central region of the gametophyte seems to be the least resistant, and from the latterly disposed protocorm, the blastema directs its growth into this central tissue (*figs. 5, 8*). The path, which the embryo is to follow, is marked out for a considerable distance ahead of it by disorganized cells (*fig. 8*).

At first the metacormal bud is throughout meristematic; but very soon there can be distinguished two growth-foci, one directly behind the other, in the axis of the blastema, and only separated from each other by a very few cells (*fig. 5*). The apical growth-focus is the growing point of the stem, and includes the entire apical region of the young metacorm. The second growth-focus is the growing point of the root. It first becomes noticeable through the apparent diverging from this area of the indefinite cell-rows which extend forwards towards the apex of the blastema (*figs. 5, 6*). It also immediately begins to cut off rectangular cells from its end towards the protocorm, which form the characteristic, parallel cell-rows of the central root cap region (*figs. 5–7*). Both growing points arise through a localization of growth activity out of one general meristematic tissue; and hence, from the first are many-celled meristems.

3. *Cotyledons and Leaves.* — The cotyledon primordia originate through a localization of growth-activity in the marginal region of the broad apical meristem (*fig. 6*). They first appear as crescent-shaped mounds of tissue, which push rapidly ahead of the stem apex (*fig. 7*). Each cotyledon has an apical meristem. Of the many embryos from Japan examined, all were dicotyledonous with the exception of two; but among the hundreds of embryos from the Missouri Botanical Garden, which have been studied, over fifteen per cent. were tricotyledons. The more common number of cotyledons is therefore two; but it is by no means constant as is usually stated to be the case. The plumular leaves, whose origin directly follows that of the cotyledons, arise in the same manner as the latter, but have a much more restricted intraseminal growth (*fig. 10*).

4. *Embryonic Tissue-Systems.* — As the blastema grows out from the protocorm, its superficial cells are irregular, and divide by periclinal as well as anticlinal walls (*fig. 4*). This condition prevails even after the stem apex has become quite distinct (*fig.* 5). Later, with the broadening of the apex, which causes a rapid increase of surface, periclinal divisions become less frequent. They, however, continue to occur for some time in the most central region of the stem apex, and can often be detected here in nearly mature embryos. Superficial cells of the cotyledon and leaf-meristems have been found dividing periclinally. In regions, other than meristems, the dermatogen appears to be morphologically distinct from the subjacent tissue.

The plerome and periblem can only be recognized as regional in the embryo, for they are not sharply marked off from each other. The first procambial tissue is differentiated in connection with the cotyledons, passing from these straight back into the body of the embryo (*fig. 7*). The next procambium-strands arise, in like manner, in connection wtth the first plumular leaves; but since these are closer together than the cotyledons, their procambium-strands are closer together. The shape of an embryo's stele is determined by these two sets of procambial strands. Hence, if there are two cotyledons, the stele will be ellipsoidal (*figs. 13–15*); but if there are three cotyledons, it will be triangularly prismoidal (*fig. 18*). At the root-meristem, an ellipsoidal plerome narrows down into a broad wedge (*figs. 11, 12*); while in the same region a prismoidal plerome narrows down into a blunt pyramid. A single procambium-strand enters each cotyledon. As it passes upward in the cotyledon, this strand, usually but not always, divides once. A few protoxylem-elements are often differentiated in the cotyledon-bundles before intraseminal growth stops.

In both plerome and periblem numerous secretory vessels are formed through the breaking down of cells in longitudinal rows (*figs. 10–12*). Many spherical resin-reservoirs also arise in the cortex of the stem, cotyledons and leaves by the disorganization of masses of cells (*figs. 10–20*). In mature embryos the cells of the cortex are packed with starch.

5. *Polyembryony.* — It often happens that when the oösphere of one archegonium of a gametophyte is fertilized, the oösphere of the other is also fertilized and two protocorms develop. Occasionally gametophytes will be found with three archegonia;

and in one such exceptional case three young embryos were found. Of the two embryos often formed in one seed, the more vigorous soon occupies the central, non-resistant tissue of the gametophyte, while the other aborts. In the many seeds examined, only one case has been found (*fig. 29*) where two embryos from different oösperms have developed to maturity in the same gametophyte. Several cases, however, have been met with, where two metacorms have resulted through the production of two blastemata by one protocorm. Figs. 36 and 37 show two such cases; while fig. 9 shows an instance where two blastemata have arisen on one protocorm, and then one has aborted.

6. *The Mature Embryo of the Seed.*—The single embryo figured and described by Seward and Gowan (1900) was, without question, a freak; for it bears little resemblance to a typical embryo. The general description of *Ginkgo* embryos given by Coulter and Chamberlain, as quoted above, was undoubtedly constructed from that of Seward and Gowan; for they describe the same anomalies as constant characters of the embryo.

A very good idea of the embryo of the seed can be obtained through an examination of the photographs of Plates XXXIV–XXXVI. Figs. 23 and 25–28 are typical dicotyledonous, and figs. 22 and 30–34 typical tricotyledonous embryos. Figs. 13–17 are sections of a dicotyledonous, and figs. 18 and 19 sections of a tricotyledonous embryo. Occasionally freakish, deformed embryos are met with, but are no more numerous than is usual in other plants. The one portrayed in fig. 35 is the only one among the hundreds examined which approximated the one described by Seward and Gowan; and the shorter cotyledon of this one was quite entire. The embryo, portrayed in fig. 24, is one of several found showing a condition intermediate between typical dicotyledonous, and tricotyledonous embryos. Fig. 20 is a section of the same embryo. In this case a third leaf was produced at the base of the plumule on the same level as the cotyledons. It was, however, partially enclosed by the functional cotyledons (*fig. 20*), and in length only equalled the plumule. The stele of this embryo was triangularly prismoidal as in the case of typical tricotyledons. Fig. 21 is a section through the cotyledons of an apparently dicotyledonous embryo, which was morphologically tricotyledonous; two cotyledon-primordia having developed conjointly, producing a single

large member. This embryo possessed the stele of a typical tricotyledon. In several similar cases noted, the primordia had assumed independent growth after a period of conjoint development, so that the cotyledons were not united throughout their entire length (*fig. 35*).

Five leaf-primordia are usually to be distinguished on the plumule of a mature embryo. In a dicotyledonous embryo, the cotyledons are often not so truly diametrically opposite each other, as are the two following leaves; one of the latter being regularly larger than the other, and occupying more space between the cotyledons (*figs. 15–17*). Beyond the cotyledons and first pair of plumular leaves, a decussate arrangement does not obtain in the embryo (*fig. 17*). In a tricotyledonous embryo, the leaves are arranged spirally and have an indeterminate divergence (*fig. 19*).

In a mature seed the embryo extends through one half to two thirds the length of the gametophyte. The cotyledons are of equal length; often slightly reflexed at their tips (*figs. 24–27*), and when the embryo is removed from the seed, they usually separate of themselves. Frequently, a considerable mass of disorganized gametophytic tissue is included between the cotyledons. The stem and root regions and also the proximal halves of the cotyledons are white; the ends of the cotyledons being yellowish or light green in color. The resin-reservoirs are most numerous in the stem and basal portions of the cotyledons, and in fresh embryos stand out as prominent greenish or amber-colored pustules.

When an embryo is placed in a chromic acid fixing solution, the root-cap region turns brown. A section (*figs. 7, 11, 12*) shows this color-change to be limited to the peripheral layer of cells; the change being due to a change in their contents. The fixing-fluid has a similar effect on the contents of the secretory vessels, and also darkens the resin-globules.

B. The Seedling.

1. *Morphogenesis.*—When seeds are placed under favorable conditions for germinating, the hard shell is cracked, at the micropylar end, by the swelling of the gametophyte. Through this opening the body of the embryo is thrust out by the elongation of the cotyledons. The root immediately turns down into the soil (*fig. 39*), and as soon as the stem is free from the

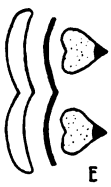
gametophyte it begins to grow in the direction opposite that followed by the root (*fig. 41*). With the elongation of the stem, the plumular leaves are quickly displaced from their original relative positions (*figs. 42–47*). The first two or three leaves directly following the cotyledons do not develop the characteristic blades, but remain small and scale-like (*fig. 47*). The stem soon stops its rapid elongation, and having expanded a rather close crown of leaves at its apex (*figs. 47, 48*), spends the remainder of the first season in strengthening and protecting itself by secondary growth in its tissues.

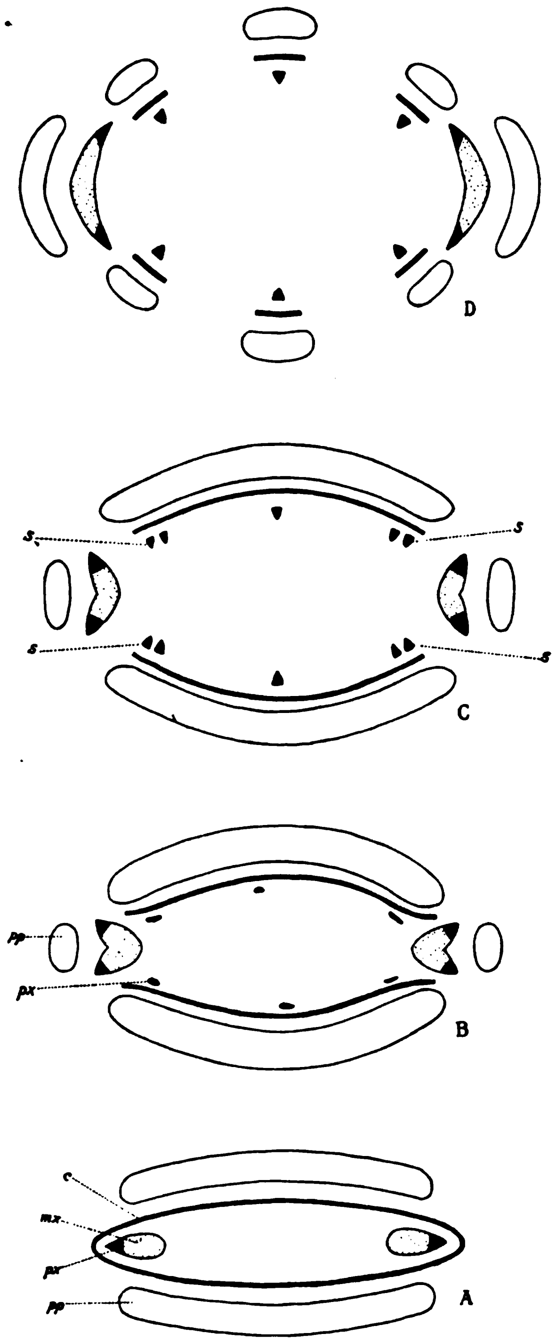
As is the rule among gymnosperms, the primary root of *Ginkgo* persists as the tap-root. During the first season it develops numerous short secondary roots (*figs. 47, 48*).

Upon the germination of the seed, the proximal portions of the cotyledons, which, as we have already noted, are well supplied with resin-reservoirs, protrude from the gametophyte as large, arching petioles (*figs. 41–44*). The portion of the cotyledon, remaining within the gametophyte, enlarges considerable, (*fig. 48*), its greatest diameter being about twice that of a cotyledon of a mature embryo of the seed. The cotyledons persist throughout the first season. Fig. 48 is a photograph of a living seedling at the end of its first summer's growth. It was taken in October, after the seedling had experienced several quite heavy frosts. The remains of the seed were removed exposing the large fleshy cotyledons, which sprang apart of themselves as soon as freed from the tissue of the gametophyte.

A large terminal bud is the only prominent one on the stem during its first winter; and, if uninjured, is the only one to become active during the second season. Fig. 49 is a photograph of a young plant which has made a considerable portion of its second year's growth. The leaves all possess fully expanded blades, and are well distributed along the stem. During its second season the plant develops a much-branched root-system.

2. *Histogenesis.* — As has already been mentioned in discussing the embryo of the seed, the first permanent vascular tissue is differentiated in the cotyledons. As the embryo begins its extraseminal development, differentiation progresses from the cotyledons towards the root-apex. The two bundles of a cotyledon unite eventually to form one of the persistent bundles which extends throughout the length of the root. If the seed-





Diagrams illustrating, in a general way, the stelar structure at various points in the transition-region between root and stem. *A*, below the transition-region; *B*, in the lower transition-region; each primary bundle dividing to form the two bundles of a cotyledon trace; C, farther up in the transition region; the four secondary bundles "*s*" later unite with the cotyledon traces; *D*, at the point of exit of the cotyledon-traces; *E*, in the petiole of the cotyledon; the two bundles still closely associated; *pp*, protophloem; *px*, protoxylem; *mx*, metaxylem; *c*, cambium.

ling has two cotyledons, the primary root will be diarch; if it has three cotyledons, the root will be triarch, a condition which Dangeard ('90) has noted in other gymnosperms. In the transition-region between root and stem, considerable diversity of structure prevails among *Ginkgo* seedlings. Yet the numerous, and seemingly very different types can be readily explained as modifications of the one general plan illustrated conventionally in the adjacent diagrams.

Examining serial sections of a seedling of about the age of those shown in figs. 42–46 we find, a short distance above the root-meristem, two xylem-bundles appearing at the ends of the elongated oval stele; and in the sides of the latter, two long arching bundles of protophloem (Diagram A and *fig. 50*). In each xylem-bundle the protoxylem lies away from, and the metaxylem towards, the center of the stele (Diagram A). Entering the transition-region the protoxylem broadens and finally divides into two masses which continue to separate as they pass upward (Diagrams B and C). With the separation of the two protoxylem groups the metaxylem is drawn out between them into a broad plate (Diagram D), and in this condition the xylem-mass passes out to the cotyledon (*figs. 55, 56, 61*). In the petiole the metaxylem plate divides, each portion continuing to rotate about its contiguous protoxylem until it reaches the position shown in Diagram E. As the xylem-bundles pass on into the blade of the cotyledon they continue to separate. The metaxylem broadens out, appearing fan-shaped in section (*fig. 58*), and in the center of the cotyledon it nearly surrounds the protoxylem, thus forming a mesarch bundle (*fig. 59*) as described by Worsdell ('97). With the first splitting of the protoxylem-bundle, as it enters the transition-region, a protophloem-group appears between and beyond its two points (Diagram B). This protophloem-bundle increases in bulk as it passes upward, and enters the cotyledon as a single bundle (Diagram D and E). Later it divides to contribute a protophloem-group to each bundle of the cotyledon (*fig. 59*).

In the lower portion of the transition-region, additional protoxylem-elements appear at various points between the cotyledon-traces, and just inside the prospective cambium-zone. Farther up, these scattered elements give place to usually six rather definite strands, which continue upward as the protoxylem-groups of the six primary bundles of the stem (Diagrams B to D and

figs. 52–57). Usually, the four secondary protoxylem-bundles, adjacent to those of the cotyledon-traces, contribute to the latter small groups of elements which unite with them just before they pass out to the cotyledons (Diagram C. and *figs.* 55–61).

While the plan of transition outlined above is often followed to a nicety in a seedling, exceptions are very numerous. The length of the transition-region varies considerably in different seedlings. As a rule, the cotyledon-traces do not leave the stele at the same height (*figs.* 51, 61), and the reduction of the traces into the two root-bundles may take place at very different levels. It is often impossible to recognize distinct bundles in the traces through the absence of protoxylem, or the indiscriminate mingling of protoxylem and metaxylem elements. The sharp limitations of protoxylem and metaxylem indicated in the diagrams are rarely met with in a series of sections.

The origin of the stem-bundles in the transition-region, is usually after the manner already described (*figs.* 50–57, 60, 61). Occasionally, seedlings are met with, however, in which the traces of the first two leaves are prominent in the transition-region, and, with the four bundles of the cotyledon-traces, form a hexarch stele, which may become resolved, lower down, into such a tetrarch stele as seen in fig. 63. Such leaf-traces are often distinctly mesarch. Then again, the trace of a single leaf may continue prominent through the transition-region, and produce a triarch stele for a considerable distance in the root. In a tricotyledonous seedling, the primary root is persistently triarch. Secondary roots are always diarch (*fig.* 62).

Secondary thickening in the stem and root of *Ginkgo* takes place in the ordinary manner. The position of the cambium in the root is shown in the diagrams and in figs. 50–57, 60–64. Below the transition-region, the pith of the root may be partially or almost wholly replaced by metaxylem (*figs.* 62–64). The centrifugal xylem becomes continuous in places with the metaxylem, but it rarely if ever comes in contact with the protoxylem. It is often separated from the latter by only a single layer of pith-cells (*fig.* 62). The growing-point of the root (*fig.* 65) presents essentially the same structure as those of the cycads and conifers which have been described by De Bary ('84). The cork-cambium of the stem arises directly beneath the dermatogen; in the root its origin is deeper seated.

The structure of the cotyledons of the seedling is illustrated

in figs. 58 and 59. The tissues of the petiole are firm, while the portion within the seed is fleshy. The cells of the region which comes in contact with the tissue of the gametophyte are densely packed with starch (*fig. 59*). The rest have fluid contents. Stomata occur on both surfaces of the cotyledon.

SUMMARY.

The essential features of the embryogeny of *Ginkgo* can be summarized as follows.

1. By free-cell-formation, following free-nuclear-division, a spherical protocorm is organized which completely fills the venter of the archegonium.
2. The basal cells of the protocorm, through continued activity, pass over into the blastema or metacormal bud.
3. The meristems of the stem and root are localized out of the one general meristem of the blastema.
4. Cotyledons and leaves arise as exogenous outgrowths upon the growing-point of the stem and are here morphologically homologous structures.
5. Cases are infrequently met with, where two embryos from different oösperms have developed to maturity in the same seed.
6. Polyembryony occurs, occasionally, through the production of two blastemata by one protocorm.

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Description of Plates.

Plates 35, 36, 37 and 39 are after photographs by Mr. C. J. Hibbard.

Plate 29.

1. Sectional view of a protocorm in which free-nuclear-division has ceased. From a section 20 thick (× 160).

2. Section of protocorm just after completion of free-cell-formation. Section 10 thick (× 160).

3. Surface view of a protocorm (× 160).

4. Section of a protocorm in the basal portion of which a blastema is being organized (× 160).

The outlines for figs. 1, 2 and 4 were traced from photomicrographs.

Plate 30.

5. Longitudinal section of a young embryo in which the position of the root-apex is just distinguishable (× 130).

Plate 31.

6. A similar section of an older embryo showing first indication of cotyledon-primordia (× 130).

Plate 32.

7. Shows relation of metacorm to protocorm. The cotyledons are well advanced and secretory canals are appearing in both plerome and periblem (× 57).

Plate 33.

8. From a section of a gametophyte containing a young embryo (× 39). To the right can be seen the empty venter of the second archegonium. Disorganization of the tissue of the gametophyte is evident for some distance ahead of the embryo.

9. An instance where two blastemata were organized in one protocorm, but only one developed into a metacorm (× 36).

10. Section of a young embryo in a plane parallel to the faces of the cotyledons, passing through the stem-apex and primordia of the first two plumular leaves (× 57).

11, 12. Two sections of mature embryos cut, the one parallel, the other perpendicular to the plane of contact of the cotyledons (× 12). These sections show, in a general way, the relation of parts, differ-

entiation of tissues and shape of meristems. The secretory canals are black. The openings in the cortex are resin-reservoirs.

PLATE 34.

13–17. Sections taken at intervals from a series of cross-sections of a dicotyledonous embryo (× 28). 13, through root-meristem; 14, through transition-region; 15, through bases of cotyledons; 16, through cotyledons and stem of plumule; 17, through cotyledons and plumular leaves.

18, 19. Sections of a tricotyledonous embryo (× 28).

20. From an embryo showing a condition intermediate between a typical dicotyledon and tricotyledon (× 28).

21. A section near the tips of the cotyledons of a tricotyledonous embryo, two cotyledons of which developed conjointly (× 28).

PLATE 35.

22–29. Embryos removed from seeds grown in Japan (× 5.5). The dark knobs, very prominent on some of the embryos, are protruding resin-reservoirs.

PLATE 36.

30–37. Embryos removed from seeds grown in the Missouri Botanical Garden (× 5.5). Figs. 36 and 37 are cases of true twinning; two metacorms having developed from one protocorm in each case.

PLATE 37.

38–46. Young *Ginkgo* seedlings about natural size.

PLATE 38.

47. A young seedling which has just completed its growth in length for the first season, slightly reduced.

48. A seedling at the end of its first season's growth, somewhat reduced.

PLATE 39.

49. A young plant early in its second year, somewhat reduced.

PLATES 40 AND 41.

50–57. Sections, selected at intervals from a series, passing from the root through the transition-region to the stem of a young seedling (× 92).

PLATE 42.

58, 59. Sections of a cotyledon of the seedling shown in Fig. 48 (× 28). Fig. 58 is through the petiole, and Fig. 59 through the thickest portion of the cotyledon. The circular openings in Fig. 58 are resin-reservoirs.

60, 61. Sections through the transition-region of a young seedling (× 60).

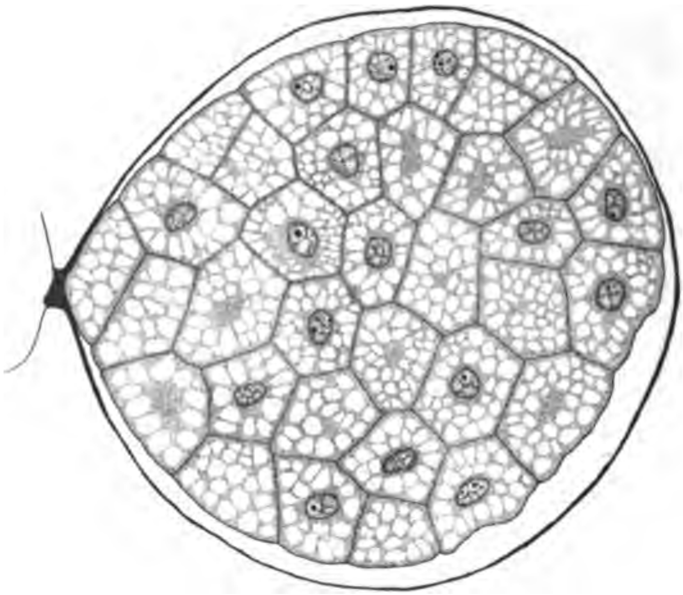
PLATE 43.

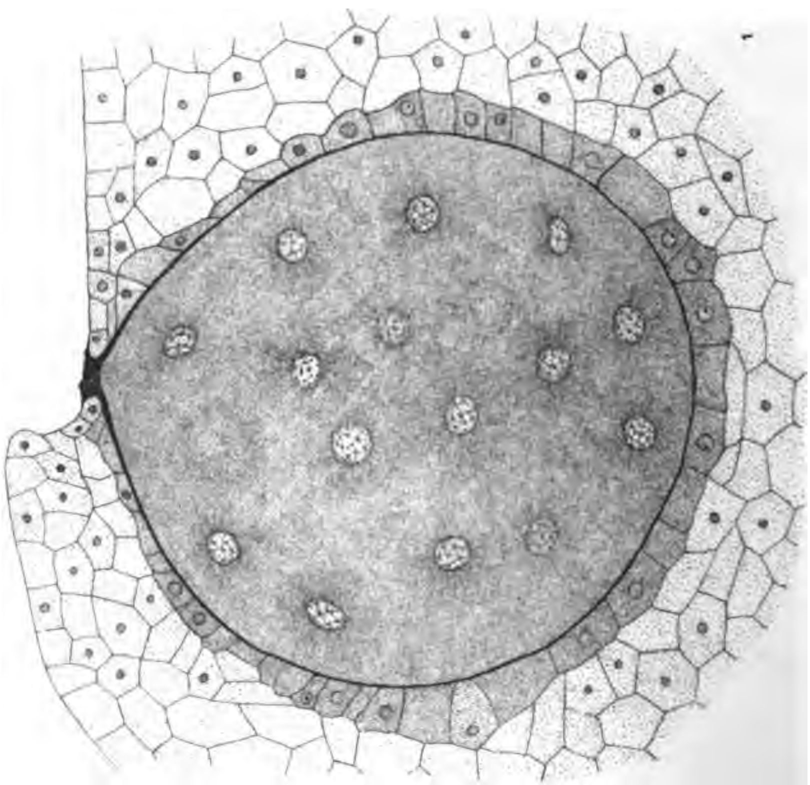
62. Cross section of a secondary root (× 62).

63. Cross section of a primary root in which the traces of the third and fourth leaves continued distinct through the transition-region, and at the point of this section, formed a tetrarch arrangement with the two cotyledon-traces (× 57).

64. Cross section of a primary root in the lower portion of the transition-region (× 25). A central mass of pith is completely surrounded by metaxylem.

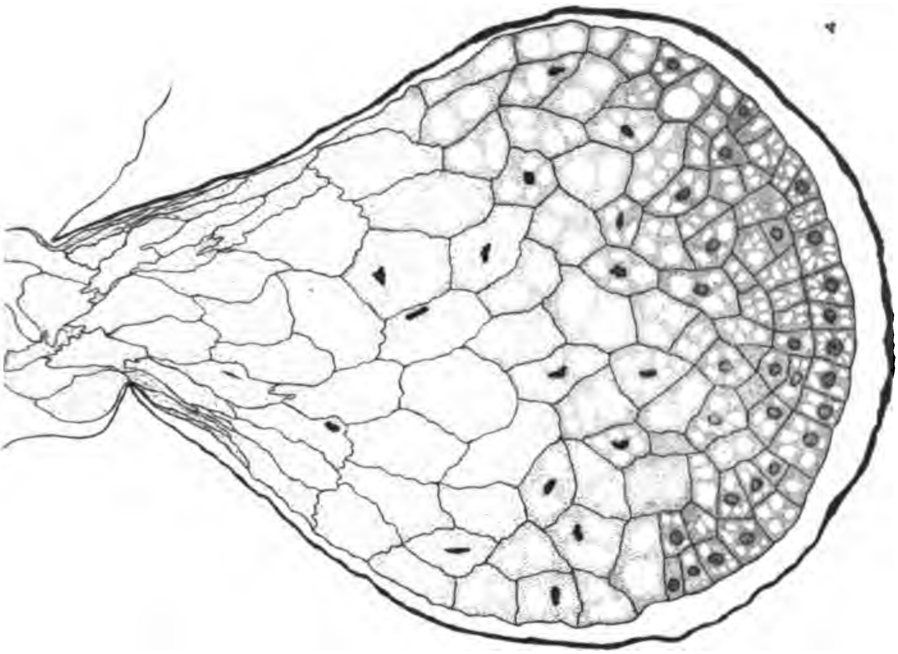
65. Longitudinal section through the tip of a secondary root (× 110). A flake of tissue, torn from the primary root, adhered to the tip of the secondary root and appears in the section.

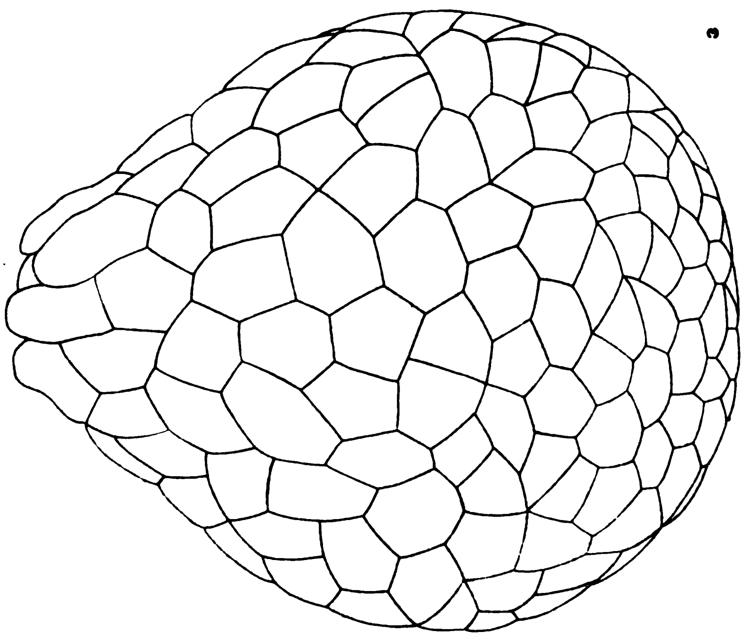




PLATE

HELIOTYPE C





ɛXIX.

BOSTON.

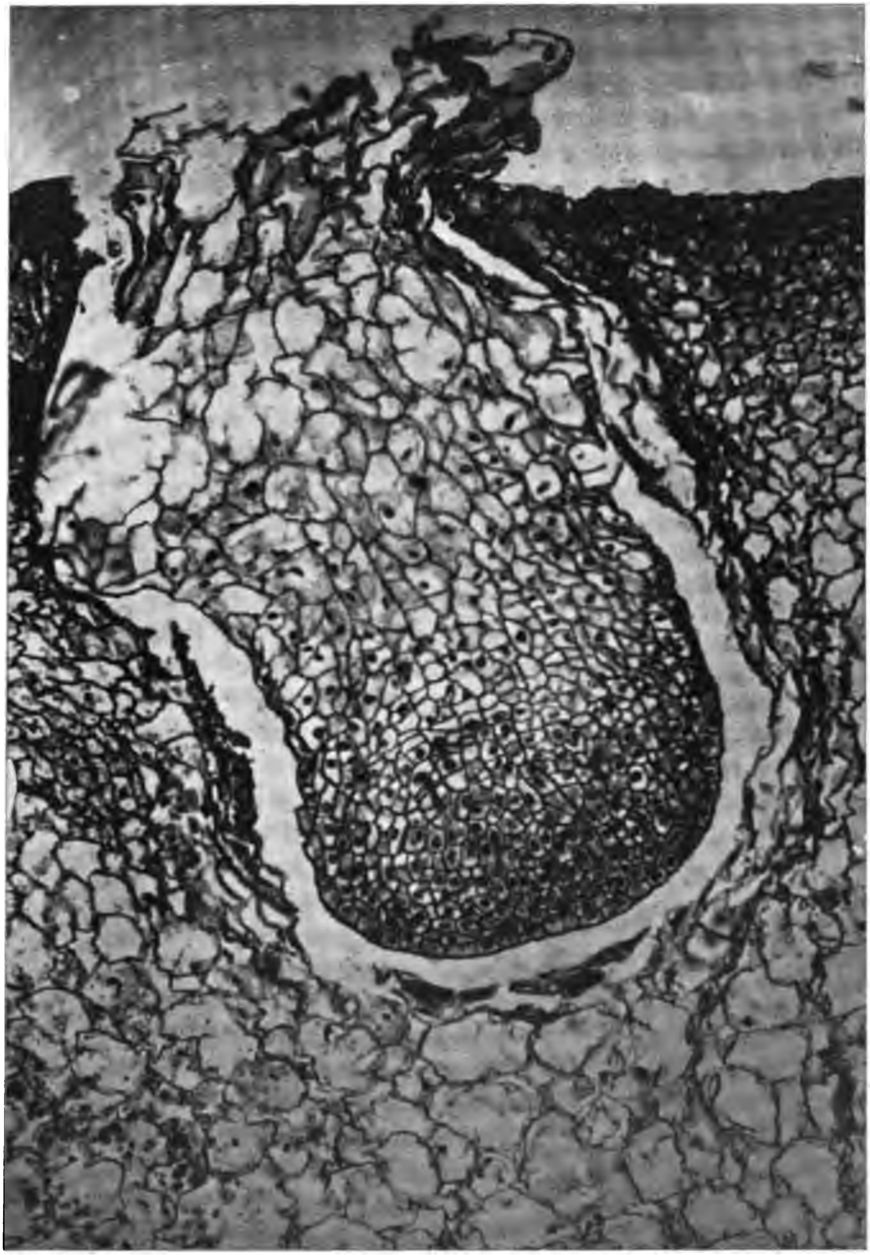


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PLATE XXX.

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PLATE XXXI.

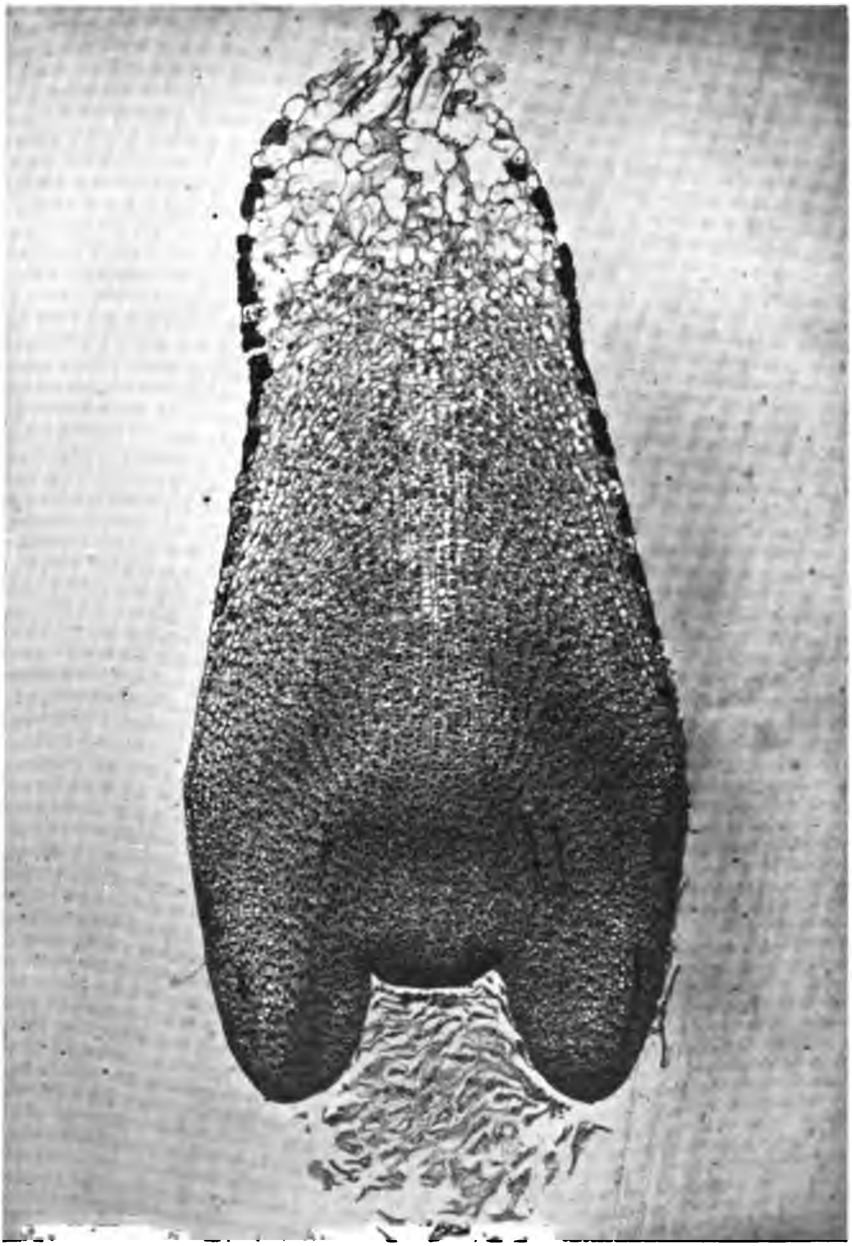

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PLATE XXXII.

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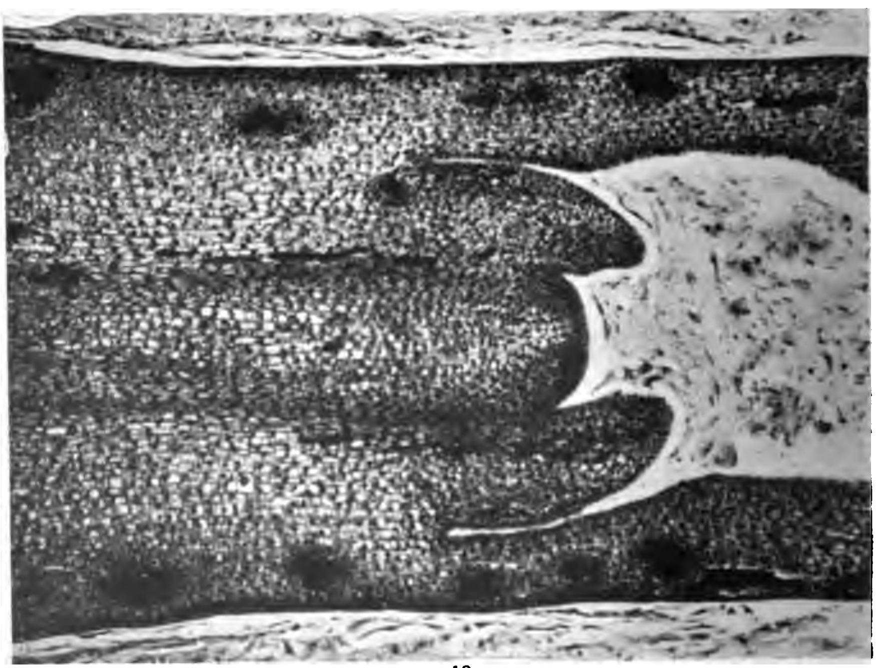

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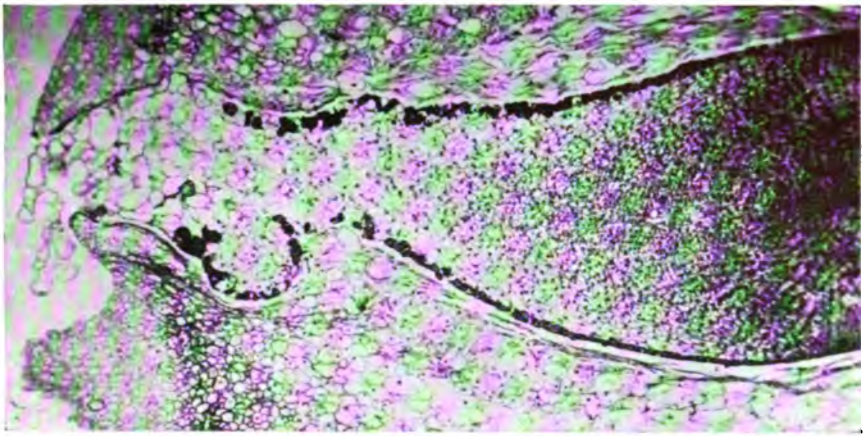
PLATE X



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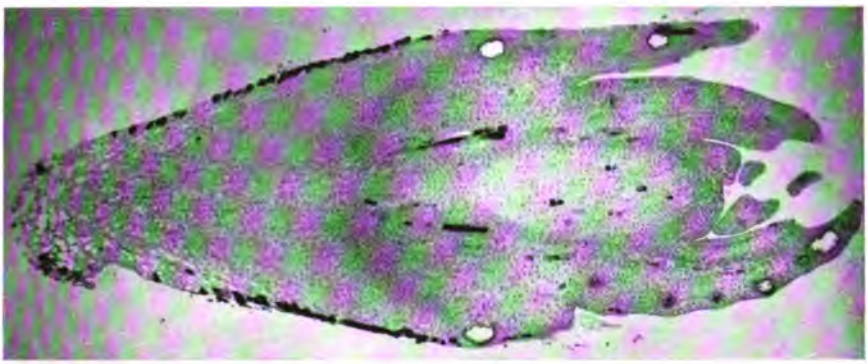

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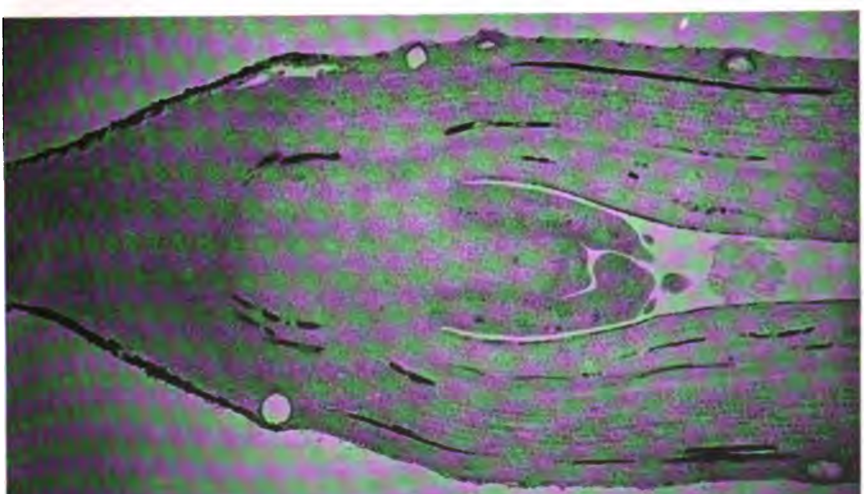

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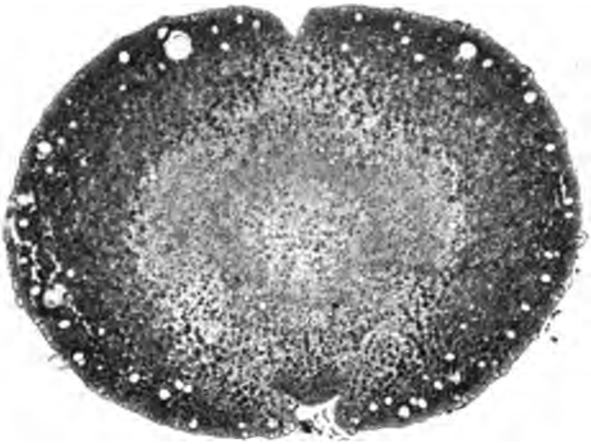

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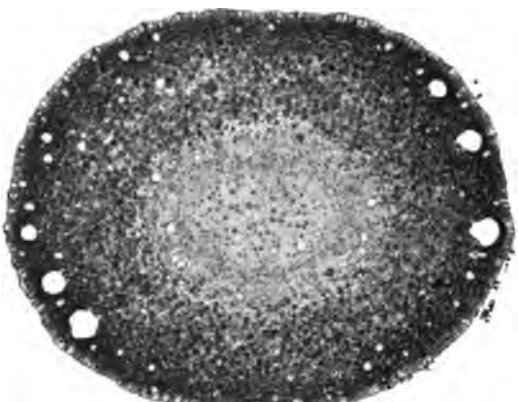

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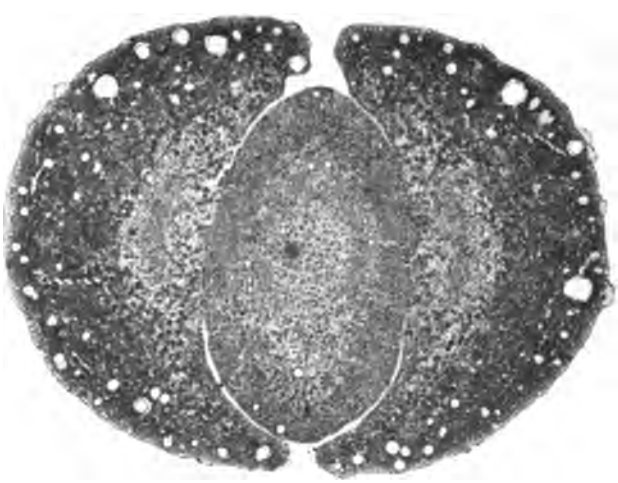

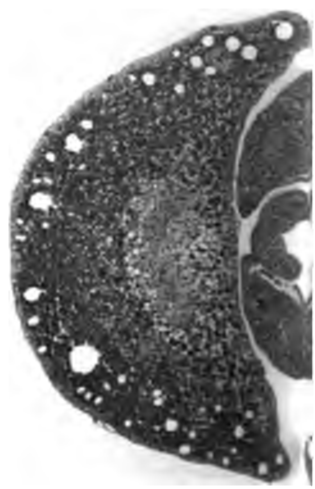

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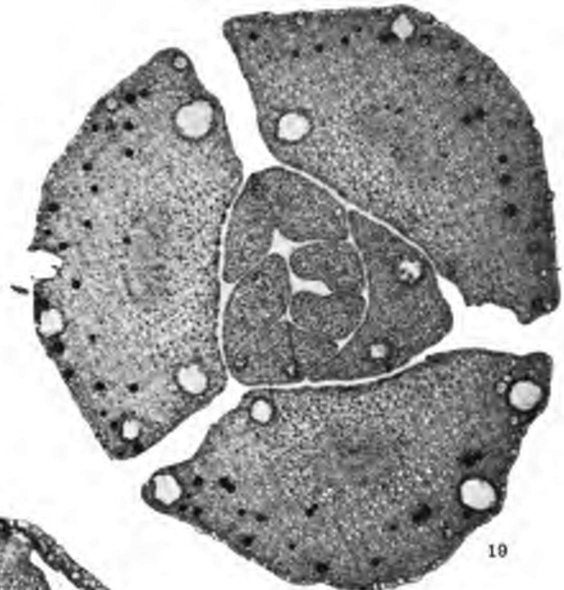

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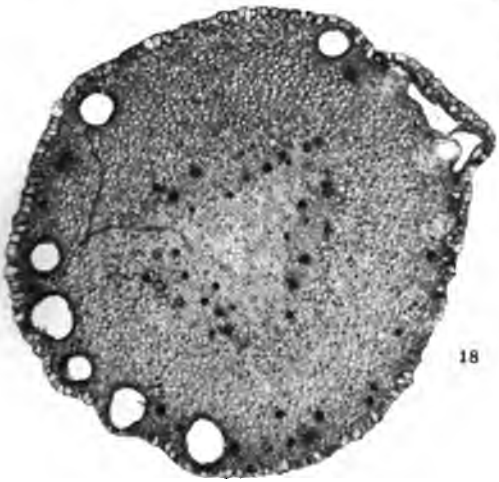

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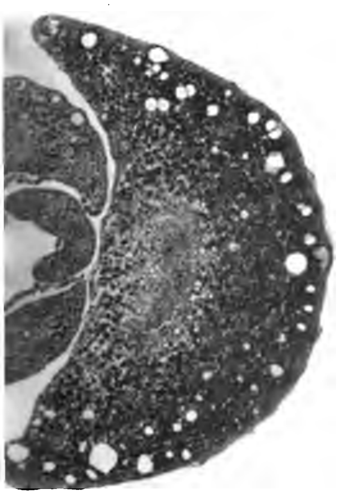

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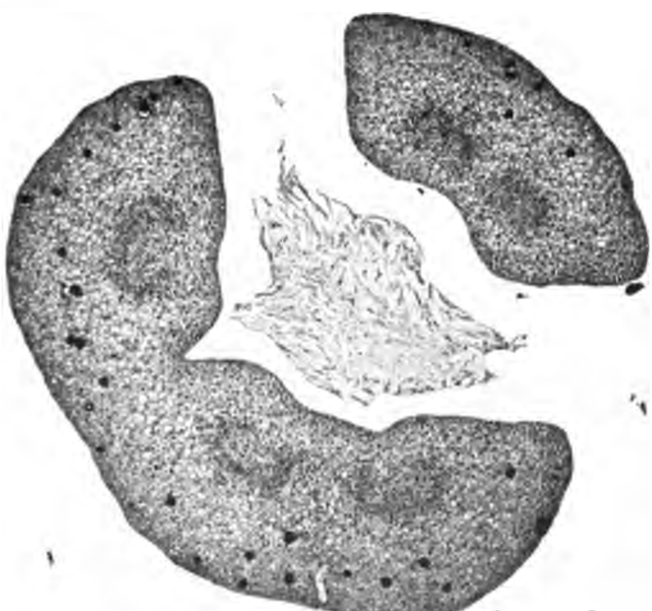

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PLATE XXXV.

PLATE XXXVI.

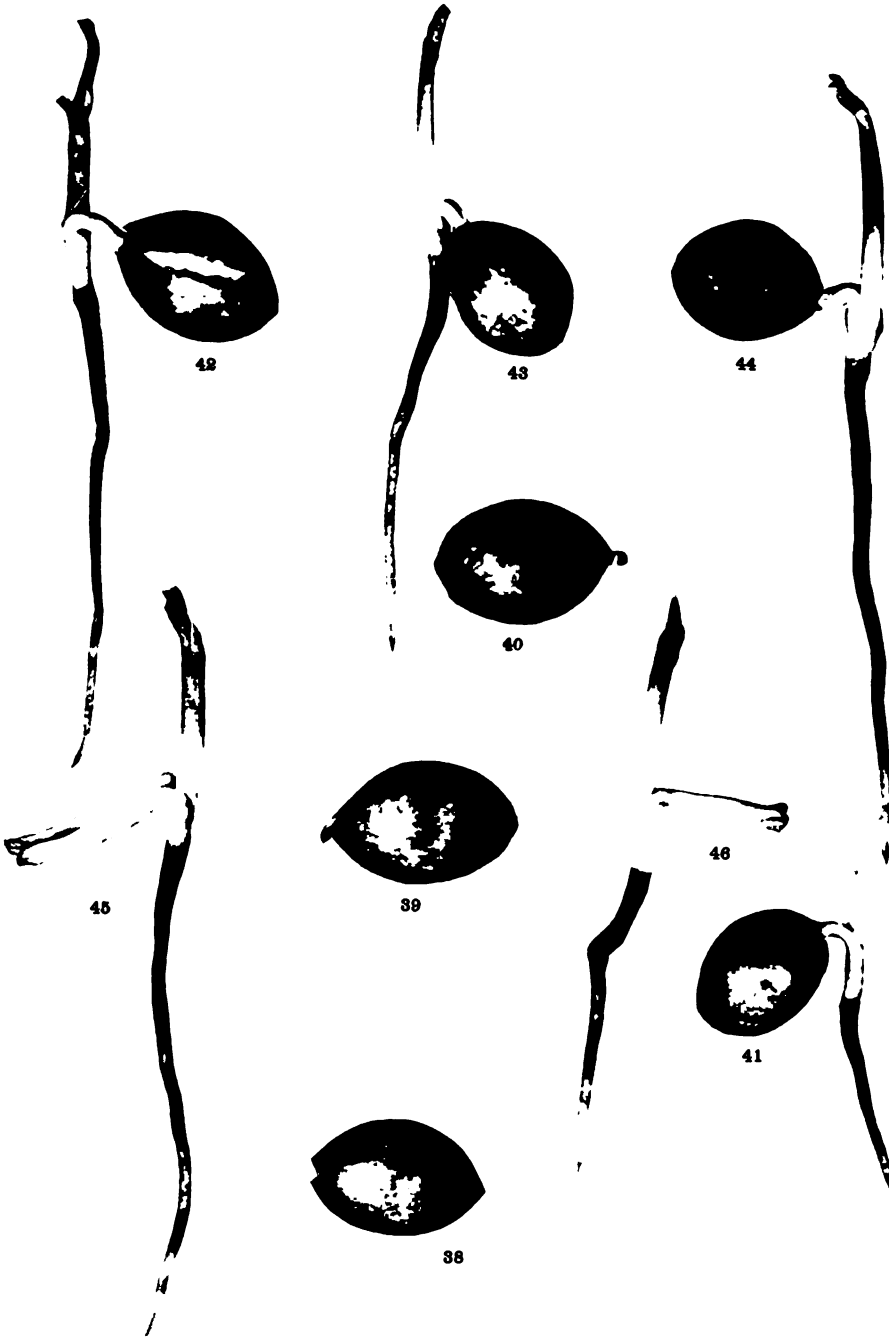

PLATE XXXVII.


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PLATE XXXVIII.

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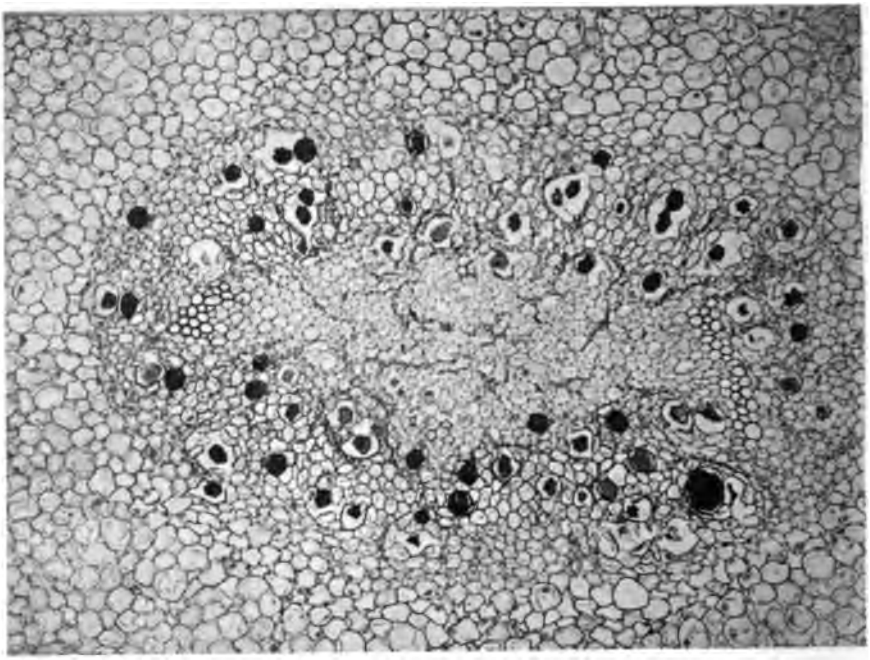
PLATE XXXIX.



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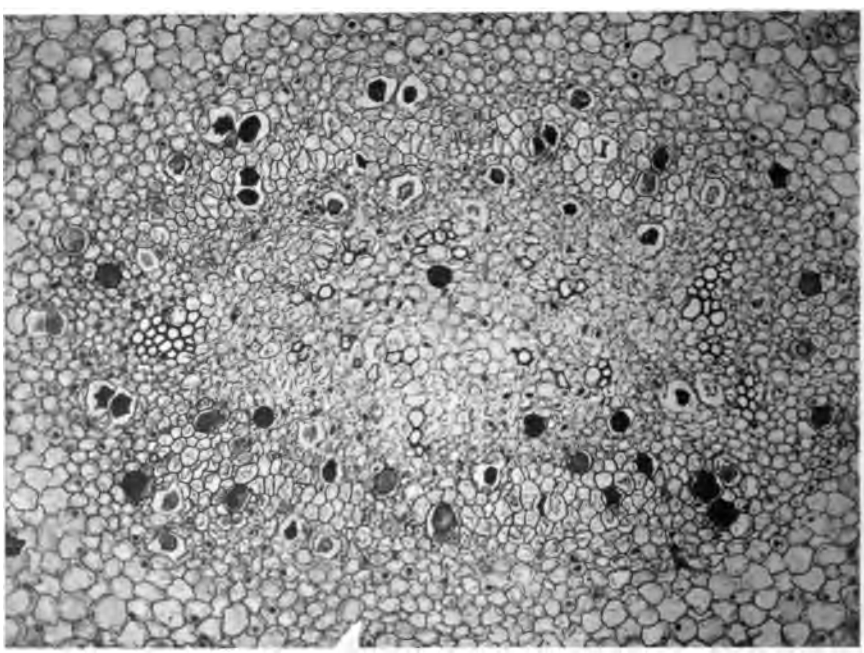

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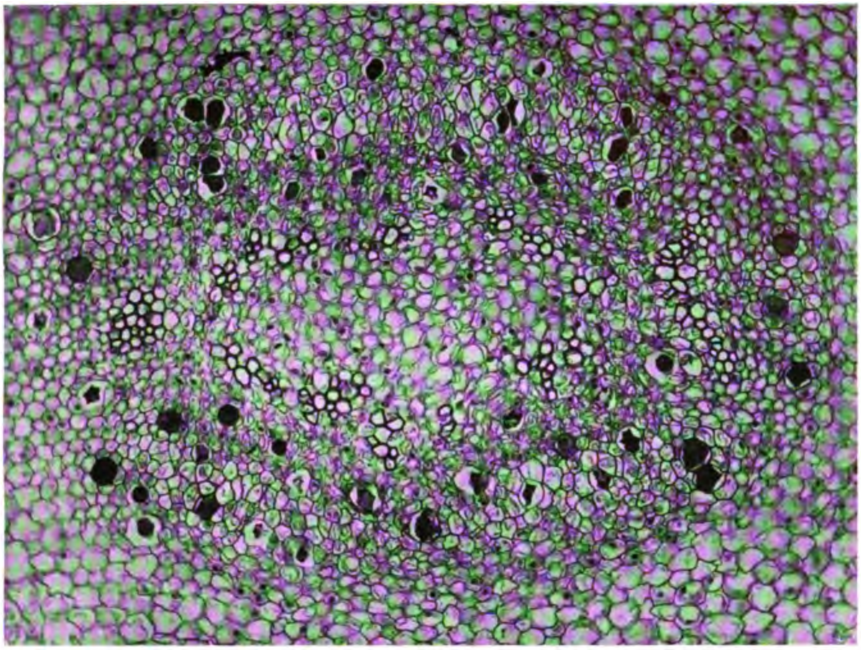

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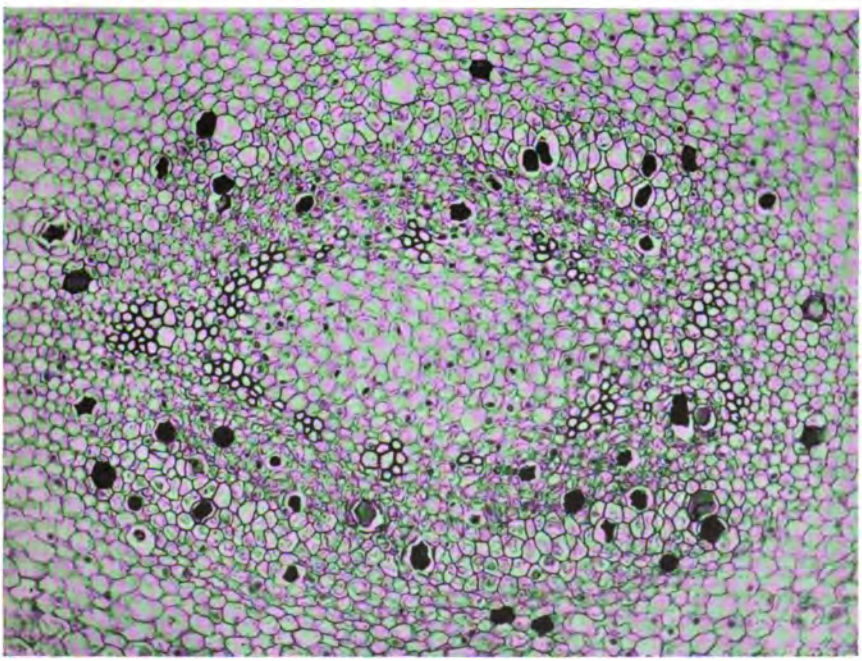

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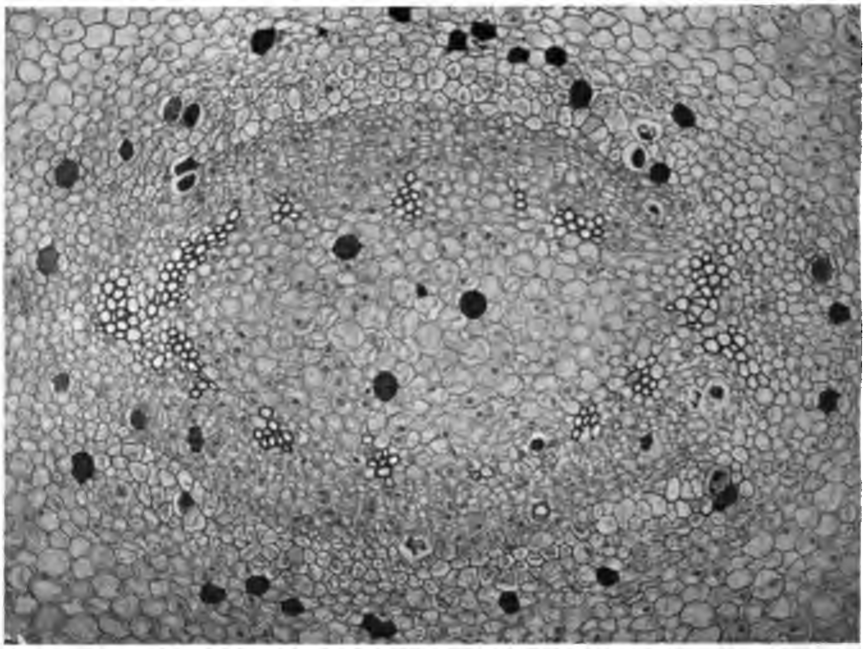

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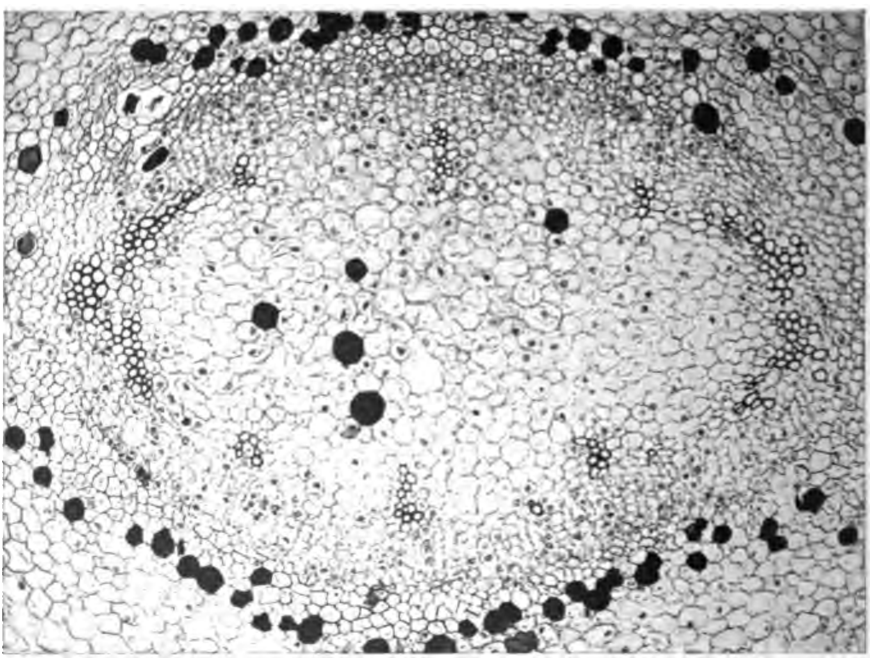

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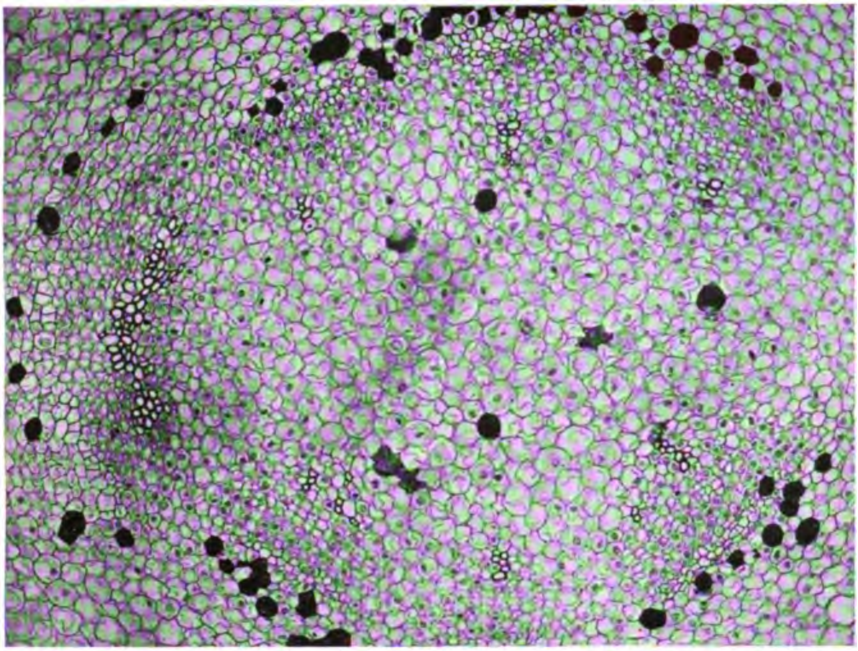

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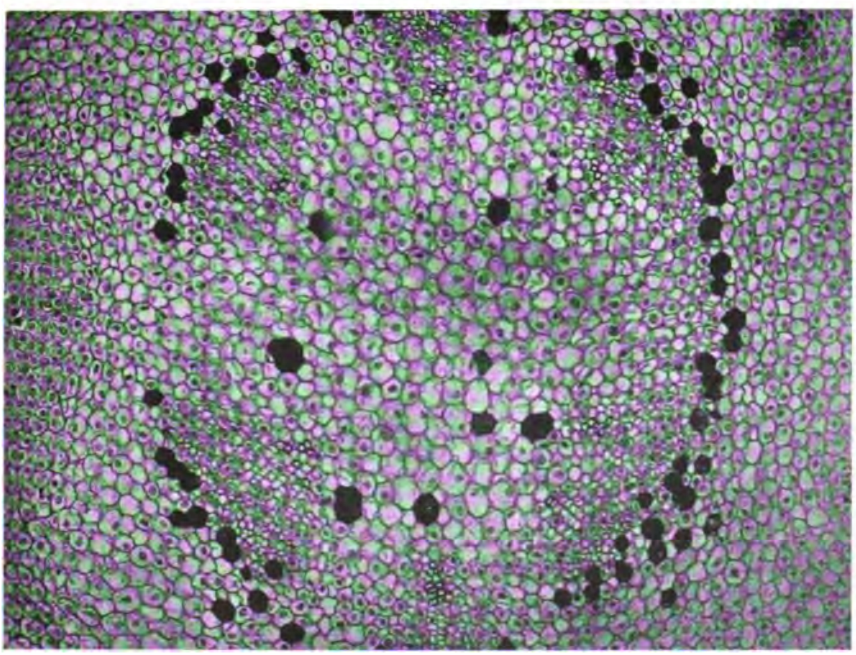

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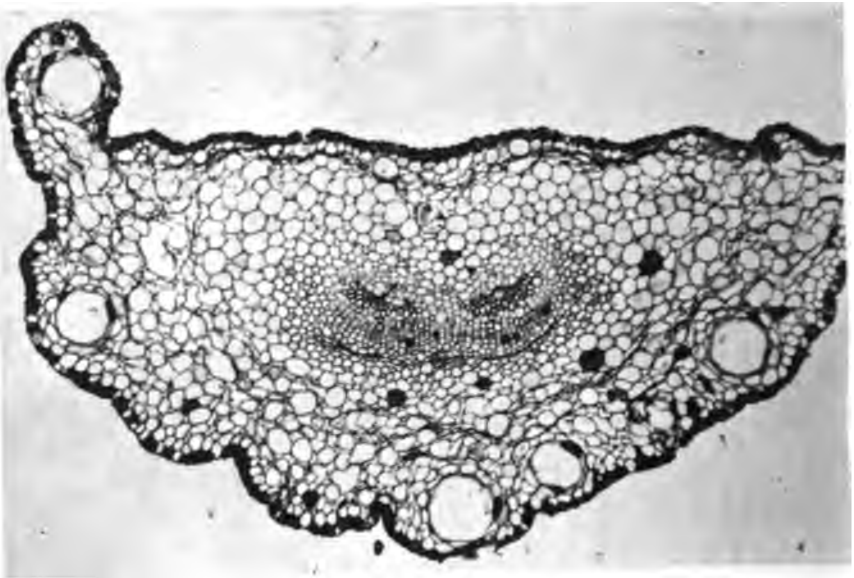

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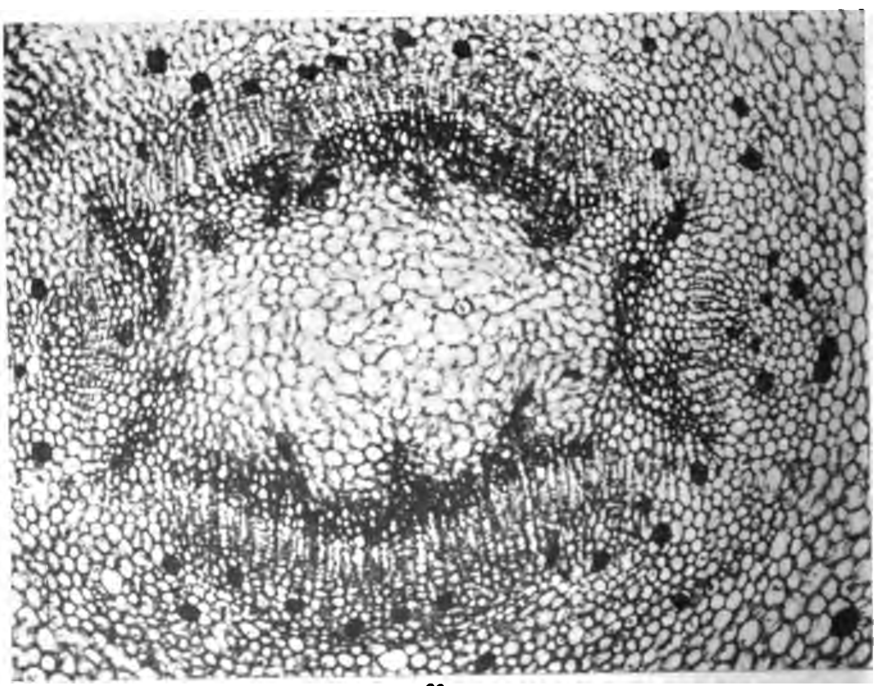

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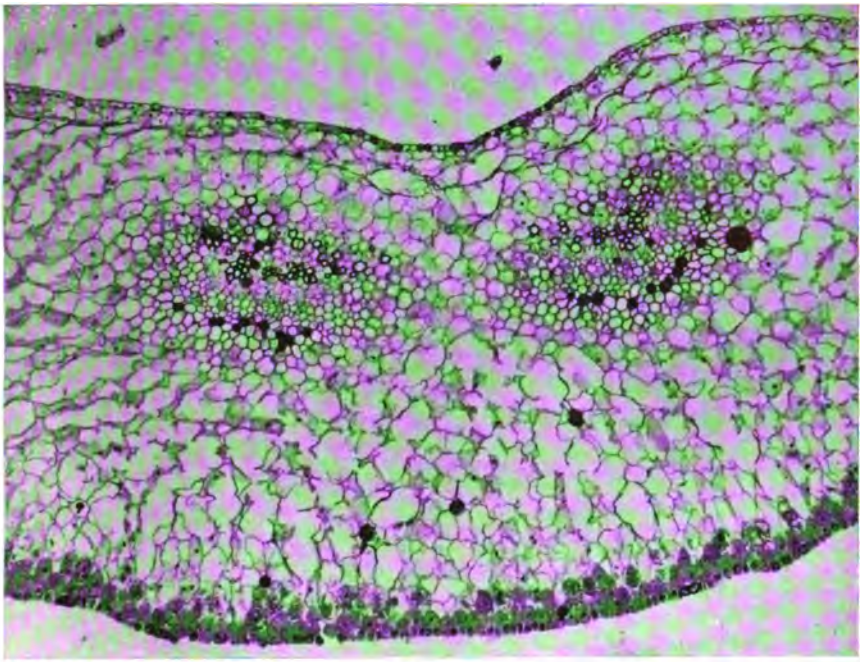

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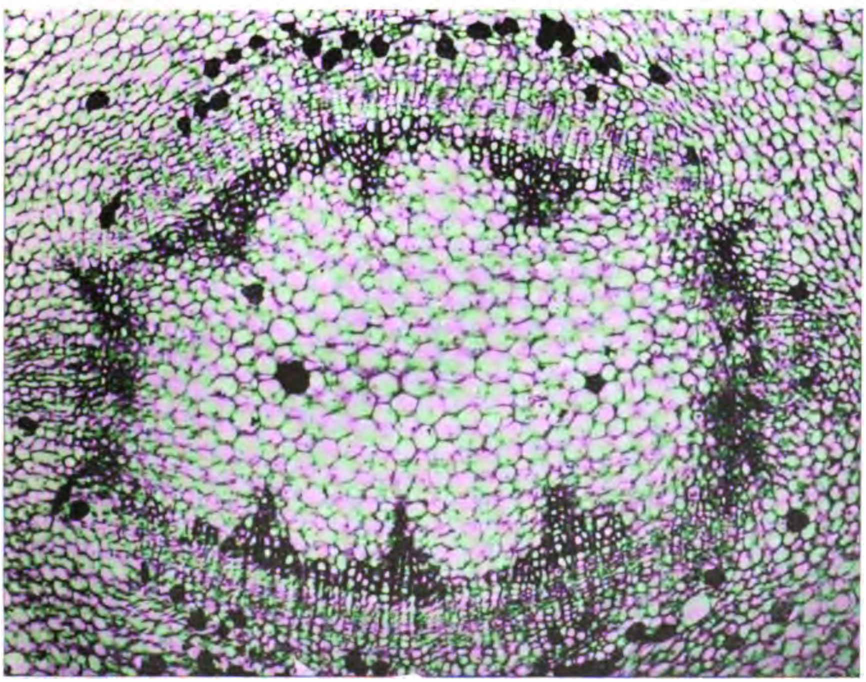

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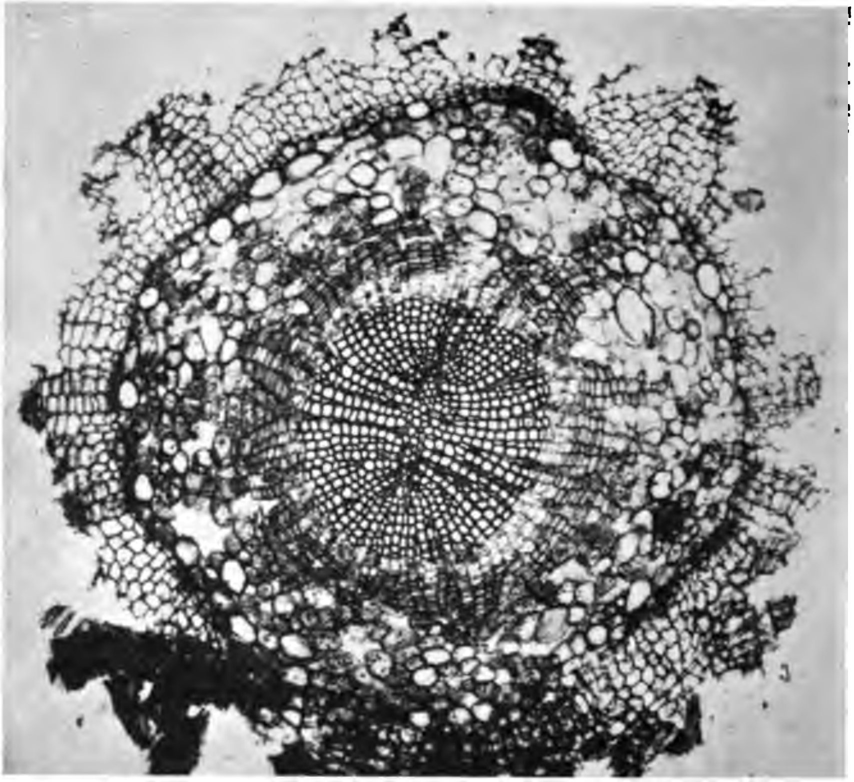

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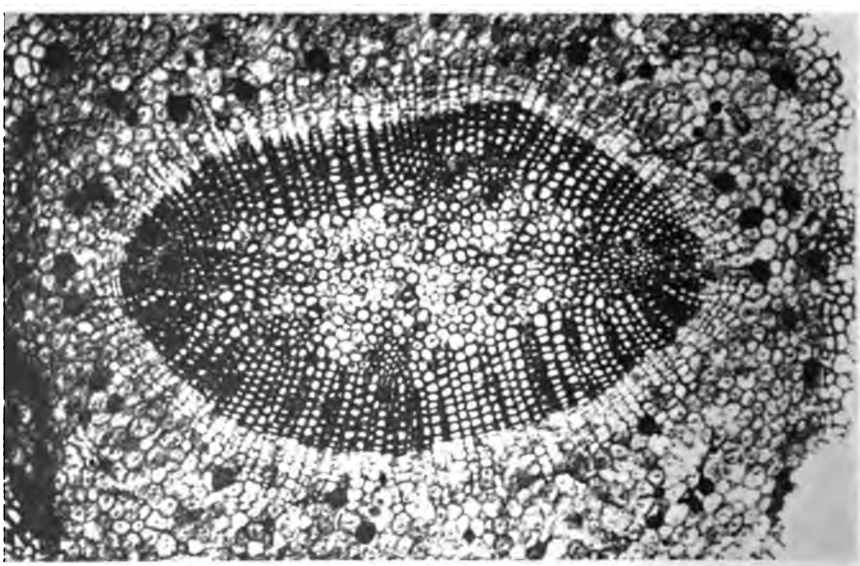

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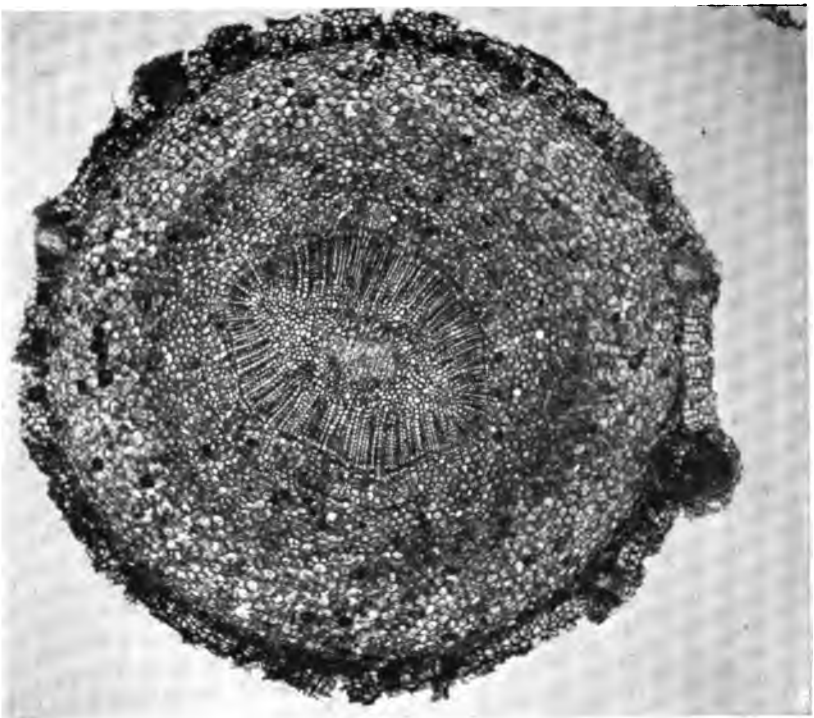

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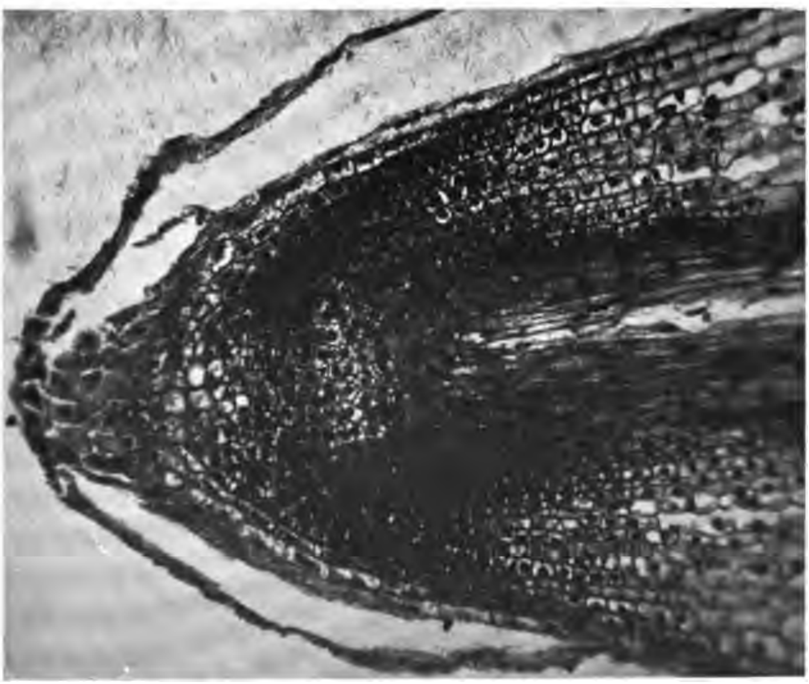

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...E XLIII.

XXIV. OBSERVATIONS ON CALLYMENIA PHYLLOPHORA J. AG.

Clara K. Leavitt.

Material.

This study was made from plants collected by the writer in July and August, 1901 and 1902, and by Miss J. E. Tilden in December, 1901 at the Minnesota Seaside Station, Port Renfrew, B. C. All the older plants were washed up on shore. Only very small young plants were collected on the rocks at low tide.

Habitat.

The plant is elittoral. It occurs in crevices in the rocky caverns where the surge is strong as the tide runs in and out. It grows in large quantities on the rocks running out from Johnson's Cove and is always to be found in the wash in the cove. It is also attached to rocks on the sea bottom and was sometimes washed in attached to the holdfast of a *Nereocystis*. Only young plants were uncovered by the low tides (—1.2 ft.) of August 2–4, 1902. The mature plants were well out beyond the low tide line, indicating that the conditions were more favorable at the lower points.

Gross Structure.

The young plant consists of a small disk-shaped holdfast, a short cylindrical stipe and one or sometimes two, entire somewhat circular laminæ (*fig. 1*). As the plant grows older proliferations appear on the margin of the lamina, each consisting of a short cylindrical stipe and a broad, flat, usually oval blade. The main central lamina later becomes thickened longitudinally from the secondary stipes on the margin to the main stipe, forming a sort of palmate veining (*fig. 2*). A tearing of the lamina between the "veins" results, and the stipe appears to have several laminæ arising from it, where originally there was but one. Often several laminæ arise from one holdfast each on a distinct stipe. The older primary fronds are dark red in color, thick, coarse and leathery, while the younger laminæ are much

finer and thinner and of the same dark red color. The secondary laminæ not infrequently arise from the surface instead of the margin of the primary frond (*fig. 2*). A third series of laminæ rising from the margin of the secondary laminæ was common, but a series of four as in fig. 3 was comparatively rare. A plant often reaches twenty-five and thirty centimeters from stipe to margin of outermost lamina. The dried specimen does not adhere well to the paper.

Minute Structure.

The material used consisted chiefly of free-hand razor sections of fresh plants gathered in the summer of 1902. The mature cystocarps were studied from formalin material collected in December, 1901, at the same point.

1. *Holdfast.* — The holdfast is comparatively small and fits like a sucker to the surface of a flat rock or curves over a projection or barnacle (*figs. 4, 5*). A thick layer of gelatine lying close to the rock fits into all uneven places and takes the impression of the rock (*fig. 6*). Above this, thick at the center and thinner at the margin, lies a layer of cortical cells covered by an epidermal layer several cells in thickness (*fig. 7*). Several holdfasts were sectioned in which a second cortical and epidermal layer appeared to have grown out over the first, so that a layer of gelatine lay within the tissues of the holdfast.

2. *Stipe.* — The main stipe was about five millimeters in length, cylindrical in form, becoming oval in cross section where it passes into the lamina. The older stipes are thicker but not longer than the younger ones.

The epidermis consists of deeply colored, thick walled, somewhat rectangular cells arranged in several rows. The cells of the true epidermis are rather larger than those of the subepidermis. Dimensions, 6.5 to 16.5 mic. in length and 6.5 mic. in width (*Plate XLIV., fig. 8*).

The cortex is made up of large, clear, colorless cells. The cells of the inner cortex are much larger than those of any other part of the plant. Dimensions, diameter 16 to 50 mic. (*Plate XLIV., fig. 9*).

In the center lie the long, narrow, thick-walled cells of the pith strand. These run mainly longitudinally, very few running transversely. Dimensions, diameter 20 mic. (*Plate XLIV., figs. 10, 11*).

Peculiar layers of tissue appeared in some of the older stipes. These remind one of annual rings. Similar structures are reported by Jonsson in such related forms as *Ahnfeltia plicata* and *Phyllophora membranifolia*. In these Jonsson found a very clear layering of the cortex marked by a difference in color and diameter of cells and formed probably by a division of the cells of the outer cortical layer.

The layers of stipe in *Callymenia phyllophora* as observed in the few older stipes collected, showed no such origin. They are irregular as to width and position, sometimes encircling the stipe, sometimes appearing on one side only. Some partial annulations were apparently due to a change of direction of the filaments of the medullary layer. Most of the filaments of one layer ran in a direction perpendicular to those of the next layer.

In other instances the annulations were apparently due to an overgrowth covering a primary cortical layer. The epidermis of the inclosed layer was somewhat disorganized and the gelatine was filled with diatoms which thus became imbedded some distance in the stem. Several layers of cortex and epidermis, distinctly marked by their imbedded parasites, appeared on one side of some stipes. In these instances the buried epidermal cells were very distinct.

LAMINA.

The lamina is made up of the same three tissues, an epidermis from three to five cells in thickness, a cortex two or three cells deep and a pith strand occupying the main cross section (*figs. 12, 13*).

The leaf is abruptly thickened at the margin, due mainly to the greater number of cells in the pith strand and cortical layer (*fig. 14*).

FRUIT.

The cystocarps form dark dots showing through the surface of the thallus when held to the light. The mature cystocarp increases only slightly the thickness of the lamina in the center of which it lies. The spores are of rounded but rather irregular form, many of them enclosed together in a compartment-like portion of the cystocarp formed by a single row of long clear cells (*fig. 15*). The cystocarp had no well defined wall as described by Carruthers for *Rhodymenia*. The spores are discharged by a rupture of the epidermal layers of the lamina just

over the cystocarp. Dimensions of spore, length 20 to 35 mic. width 13 to 20 mic.

Young cystocarp material was collected late August, 1902, showing the oögonium and accessory cells in figs. 16 and 17.

The stages of development described in *Callymenia* J. Ag. by Bornet could not be made out.

Parasites.

Microcladia coulteri. — This plant occurred parasitic on nearly every plant collected. The largest found was six centimeters in length. It is usually found on the margins of the fronds but sometimes occurs on the surface. A section through the lamina of the host shows the rounded base of the parasite standing in a cup-like depression of the host thallus formed by the disappearance of the epidermal cells. Long rhizoid-like cells project from the short rounded cells at the base of the parasite down between the cortical cells of the host (*Plate XLV., fig.* 1).

Callithamnion sp. — Almost all laminae showed at some point traces of this parasite. The primary frond is frequently covered with a fine short downy mat of it. Plate XLV., fig. 2, shows a young filament extending up from the surface of the host thallus. Beneath the surface the parasite sends down a long rhizoid to the pith strand of the host through which it ramifies. This rhizoid sometimes branches in the pith strand. Above the surface the *Callithamnion* shows its characteristic branching. Plate XLV., fig. 3 shows this parasite in the tetragonidial condition.

Comparison of Microcladia and Callithamnion.—The former is comparatively large, is borne on the margin of the thallus and its penetration into the pith strand was slight, not branching in any direction. The latter was either invisible to the naked eye or appeared as minute down on both surfaces of the host thallus. It penetrated through all parts of the host as a single branching filament.

Porphyra sp. — Young *Porphyra* plants were found growing epiphytically upon this parasitic *Callithamnion*. Plate XLV., fig. 4, shows such a plant consisting of a filament of four cells which broadens out to form the characteristic flat thallus of Porphyra. At the base the filament forks, forming two branches of three cells each, which served as a holdfast.

Chlorochytrium inclusum. — A section cut in fresh material August 12, 1902, showed a mature vegetative stage of this parasite, Plate XLV., fig. 5. It corresponded very closely to the parasite on *Constantinca rosa marina* found and described by Mr. E. M. Freeman. Dimensions: 150 mic. × 75 mic.

It was oval in form and was inclosed in a thick cell wall which protruded beyond the epidermis of the host. The parasite lay mainly in the epidermis scarcely extending into the cortex of the host. Several distinct pyrenoids could be distinguished in the bright green chlorophyll.

Endophyte, genus unknown. —This parasite was to be found in the great majority of the sections cut in the laminæ. It occurs but rarely on stipe or holdfast. It is usually distinctly vase shaped with the interior of the vase toward the interior of the lamina. It often lies entirely in the subepidermis and never extends beyond the surface of the host. The larger ones extend down into the outer cortex. Each is enclosed in a thick wall. The contents are homogenous, granular and vary from an almost colorless to a yellow green in color. Often what appears to be a large oil drop lies in the base of the vase. The parasite consists often of two and sometimes of three or four cells (Plate XLV., fig. 6), one large cell in the base of the vase and one or two in the narrow neck. The larger plants are often one celled, Plate XLV., fig. 7, and the small ones are sometimes two.

Dimensions: length 35 mic. to 140 mic. width 25 to 45 mic. Plate XVL., fig. 8, shows diagramatically the relative positions of the cystocarp and the two parasites *Callithamnion* and ——.

Explanation of Plates.

Plate XLIV. figures *Callemenia phyllophora f. orbicularis* as to general habit and structure. Plate XLV. figures various parasites upon the plant.

Plate XLIV.

1. A young plant about half natural size.
2. Older plant with secondary laminæ rising from margin and surface, about one half natural size.
3. Mature plant consisting of series of four laminæ, about one half natural size.
4. Joint holdfast of young and mature frond attached to clam shell, about natural size.
5. Side view holdfast, natural size.
6. Sucker-like under surface of holdfast, natural size.

7. Cross section of epidermis and cortex of holdfast, × 250.
8. Cross section through epidermis and cortex of stipe, × 250.
9. Detail of cortex cells of stipe, × 250.
10. Cross section through pith strand of stipe, × 250.
11. Longitudinal section through pith strand of stipe, × 250.
12. Cross section through epidermis of lamina, × 250.
13. Cross section through cortex and pith strand of lamina, × 250.
14. Diagram of cross section of leaf showing thickening of margin due to increase of cortex and pith strand, × 30.
15. Section of cystocarp showing spores inclosed by row of clear cells, × 250.
16. Oögonium and accessory cells among cortical cells of lamina × 250.
17. Another oögonium and accessory cell, × 250.

PLATE XLV.

1. Outline of young thallus of *Microcladia coulteri* from the base of which project long rhizoid-like cells into the cortex of the host plant, × 170.
2. Young filament of *Callithamnion* among cells of host, × 170.
3. Filament of *Callithamnion* bearing tetragonidia, × 170.
4. Young frond of *Porphyra* epiphytic on parasitic *Callithamnion*, × 170.
5. *Chlorochytrium inclusum* lying in epidermis of host, × 170.
6. Endophytic parasite of unknown genus consisting of four cells, × 170.
7. Same parasite surrounded by epidermal cells, × 170.
8. A diagram of cross section of lamina showing relative positions of cystocarp, parasitic *Callithamnion* and endophyte, × 20.

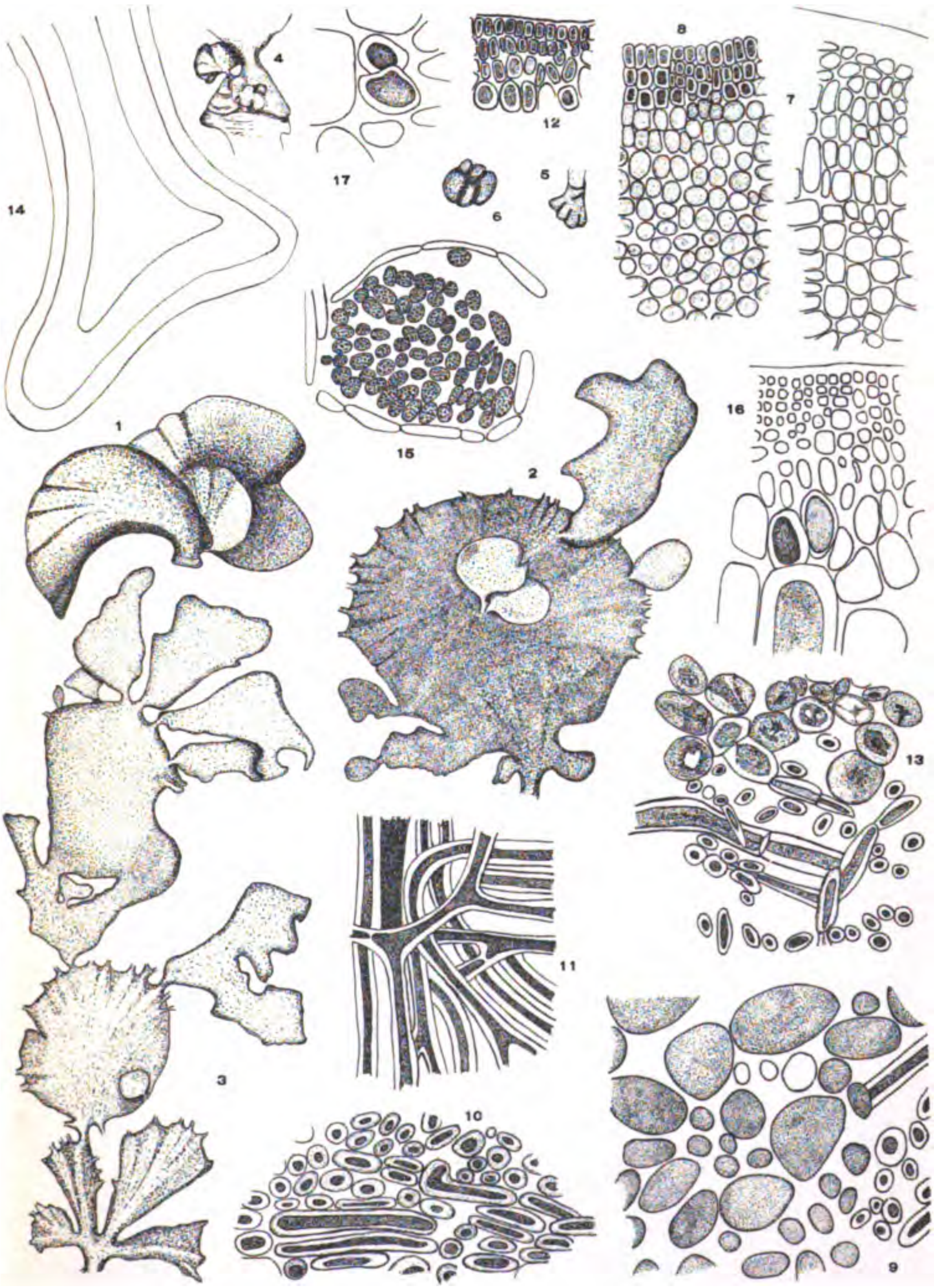

PLATE XLIV.

HELIOTYPE CO., BOSTON.

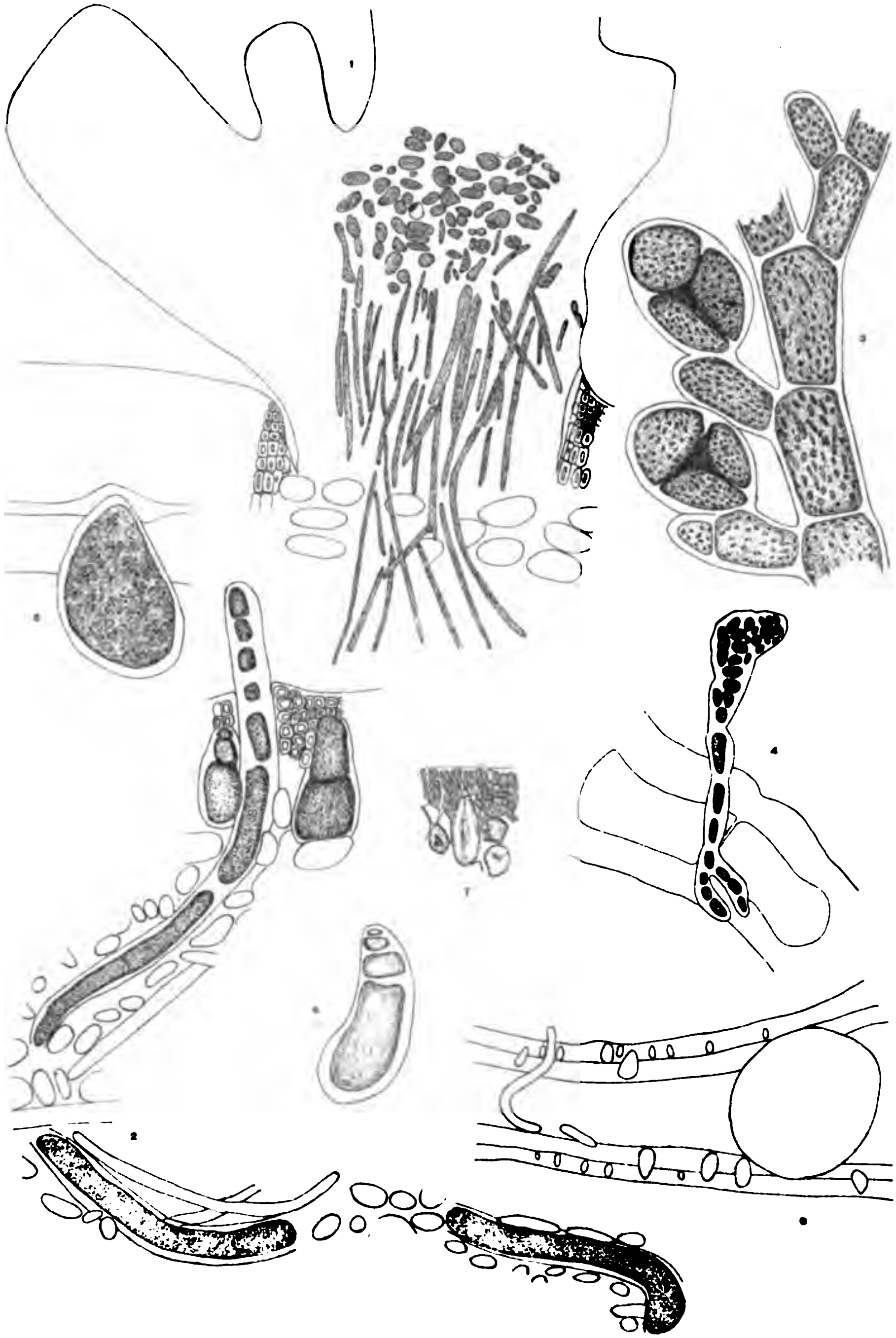

PLATE XLV.

HELIOTYPE CO., BOSTON.

XXV. OBSERVATIONS ON ENDOCLADIA MURICATA (P. AND R.) J. AG.

FLORENCE M. WARNER.

The collections upon which this paper is based were made at the Minnesota Seaside Station in August, 1902.

This species was given the same name by two different students of algæ at about the same time. Harvey gave the name *Gigartina muricata* to a form from San Francisco in 1839 or early in 1840 while Postels and Ruprecht gave the same name to a form of the same species in 1840. Harvey describes the plant (Ner. Bor. Am., p. 182, *pl. 27, B*) as follows: "The frond is formed of a simple, jointed axial filament of large diameter, with internodes containing endochrome and about thrice as long as broad, coated externally by a thin stratum of minute cellules, from which radiate to all sides numerous, dichotomous, moniliform, horizontal filaments, whose apices, strongly soldered together, unite to form the periphery. The substance is firmly cartilaginous, rigid when dry, Color a very dark brown. Conceptacles spherical, sessile on the ramuli."

Schmitz and Hauptfleisch in Engler and Prantl's Die natürlichen Pflanzenfamilien, describe *Endocladia* and figure the three-celled carpogonial branch with the auxiliary cell which form the procarp of *E. vernicata* J. Ag. The thallus, according to the above, is cylindrical, very much branched on all sides with small hooked spines, and has a distinct filamentous structure. There is a rather thick, long-jointed central axis, with an alternating, inclined, jointed apical cell. This sends off in alternate order dichotomously branched filaments which grow diagonally upwards. These branches are more loosely constructed and longer jointed toward the center, but toward the cortex become smaller celled and closer, lying finally side by side. The inner layer is more or less quickly traversed with dichotomously branched short-celled rhizoids. The central axis is surrounded by numerous analogous filaments running lengthwise. Gonidia are found in great numbers in the thickened branches of certain sections of the thallus. Procarps are

found in the somewhat loosened, fruit-bearing section of the thallus appearing in great numbers in the central part of the cortex. A short, two or more celled, many forked, small secondary side-branch of a filament forms an auxiliary cell from an end cell. Near the auxiliary cell is developed a three-celled carpogonial branch bent in shape of a hook. The gonimoblast apparently arises from the fecundated auxiliary cell, branches profusely, at times towards the center, into the somewhat loosened tissue of the inner layer. The branches of the gonimoblast creep between the rows of cells of the sterile tissue, often fusing with these cells, and finally the end cells develop into spores.

The fruit-body is an irregular mass of interlacing fibers of which the lower, stronger sections of the branches stand out plainly, with numerous spores irregularly massed in the interstices. The cystocarp, without a special protective layer, is sunk in the locally, slightly thickened thallus. It protrudes slightly to one side of the thallus near the short spiny point of a branch. The fruit wall formed by the local thickening of the cortex of the thallus does not show a pore.

The same authors describe the reproductive organs of the Gigartinaceæ as follows: Reproduction occurs both sexually and non-sexually. The tetraspores are strewn over the surface under the outer cortex or in many irregular groups and then sunk in the inner cortex of the thallus, or arranged in projecting nemathecia. The sporangia usually divide transversely but they also divide obliquely (*Endocladia*).

Antheridia are spread over the upper surface of the thallus, sometimes in the form of small, cup-shaped capsules, opening outwards, and sunk in the outer cortex of the thallus.

The carpogonial branch develops from a lateral branchlet of a primary branch. The carpogonial branch is three-celled, bent inwards like a hook, and connected with the swollen auxiliary cell, rich in contents. The fecundated auxiliary cell grows inwards and develops the gonimoblast branches. The end cells of these branches are transformed into spores.

Endocladia hamulosa (Ruprecht) J. Ag., described in De-Toni's Sylloge Algarum, seems to differ from *E. muricata* only in the position of the cystocarps. "*E. hamulosa* seems to differ from *E. muricata* only in having the cystocarps at the bases of the ramuli, while in the latter species they are simply

lateral. We have found both sorts on the same plant so it has seemed best to include both under the same name"—Setchell and Gardner. This is true also of the specimens examined by me.

Endocladia muricata (P. and R.) J. Ag. is a red alga belonging to the genus Gigartinaceæ. The plants studied at the Minnesota Seaside Station, Vancouver island, seem to be the typical form. Setchell and Gardner describe two other forms, *E. muricata* forma *compressa* and forma *inermis*, but as the specimens in hand have not a particularly flattened frond and are not destitute of spines, they are probably neither of these forms.

The plants were found growing on rocks and boulders in the upper portion of the littoral zone very near high water mark. They were fastened quite firmly to the substratum. The fronds are low, from 2–4 cm. in height, shrubby in appearance, and very dark red or brown in color. The branching is dense and irregular and the branches are profusely covered with spines. The frond seems to proceed from a branch which runs horizontally along the surface of the substratum. This horizontal branch sends off downward branches at the ends of which holdfasts are developed. Upright branches develop into the frond.

Frond.—Examining a longitudinal section (*Plate XLVI., fig. 4*) of the frond a conspicuous central cylinder is seen surrounded by a mucilaginous sheath. This axis is divided into cells about three times as long as broad. There appear to be protoplasmic connections running through the dividing cell walls of the axis cylinder. Branches are given off quite regularly from this central axis, the branches arising just below the cross walls of the central axis, and often from two sides of these cells. These branching filaments do not extend radially out to the cortex as described by Harvey, but rather diagonally upward and outward, terminating in the cortex opposite the lower part of the third cell of the central axis from which they started (*Plate XLVI., fig. 4*). The branching seems to be more or less regular (*Plate XLVI., fig. 2*). Two branches are given off from the upper third of the cell, following somewhat the method of branching of the central cylinder. The branching, in this way, seems to be quite regular for about eight cells, when it sends off two branches, each of these branching dichotomously until the cortex is reached. There are, however, exceptions to this rule.

Massed around the central axis are small round cells. These seem to have developed, at least in some cases, from the upper branch (*Plate XL VI., figs. 2, a*, and *3, a*) of the original branch coming from the central axis. Schmitz and Hauptfleisch speak of these rounded cells as rhizoids, while Harvey does not discuss their origin, but speaks of them as coating the axis. In the material studied the branching was not always dichotomous nor did the branches run radially outwards. The filaments in the center of the frond are loosely scattered, being massed together closely to form the cortex. Examining a cross section of the frond we find a large round central cylinder (*Plate XL VI., fig. 1*). Massed around this cylinder are small round cells. The cells in the center of the section are not connected with filaments showing that the filaments of which these cells are cross sections run parallel to the central axis. The tissues are loosely arranged, but towards the periphery dichotomous branching can be observed and these branches held together by a gelatinous secretion form the periphery.

Holdfast.—The holdfast is strong, although quite inconspicuous. It does not appear to be disc-like, but rather to be composed of branches (*Plate XL VI., fig. 7*). There is a brown cellular substance which is developed beneath the holdfast. Apparently the holdfast can be developed at any point where the horizontal branch may come in contact with the substratum or at the ends of the small branches which radiate downward from the horizontal branch.

Asexual Reproduction.—Some branches appear slightly fleshier than others. When sectioned there are found distributed around them, the tetragonidia. These are developed from the peripheral cells. In one section (*Plate XL VI., fig. 8*) we may find the younger gonidangia the contents of which are not yet divided, those which have divided obliquely forming two masses, and the mature tetragonidangium containing four gonidia. As has been previously stated they do not divide perpendicularly but obliquely. *Plate XL VI., fig. 8*, illustrates a portion of a longitudinal section drawn from the side of the axis cylinder to the periphery. The same structures would be seen on the other side of the axis cylinder. Long narrow paraphyses extending as far again as the tetragonidangia are found which function as a protection for the gonidia. They are developed from certain peripheral cells and are made up from fourteen to sixteen cells.

Sexual reproduction.—The cystocarps are found on the branches, sometimes singly, often two on one branch, in which respect this species differs, as has been stated, from *E. hamulosa.* Beyond the cystocarps, sterile tissue extends in the form of a projection or spine. In a cross section of the cystocarp (*Plate XLVI., fig. 5*) slender branching filaments pass in and out among the carpospores. The gelatinous sheath of these filaments is not plainly seen here, the protoplasmic contents alone being visible, and the cells of the filament have become very much distorted. The carpospores are uninucleate and vary in shape, some being spherical, some oblong and others oval. The wall of the cystocarp has the characteristic structure of the wall of the frond. Distorted branches connected at times with the cortical cells are found ramifying through the structure. The development of the cystocarp has been given previously in the paper as described by Schmitz and Hauptfleisch.

The author desires to thank Professor Conway MacMillan for suggesting the subject for study, Miss Josephine E. Tilden for a detailed outline of the work, and Professor R. A. Harper for encouragement and helpful suggestions during the progress of the work.

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Explanation of Plate XLVI.

All drawings were made by the aid of a camera lucida.

1. Cross section of the frond. Central axis; small cells surrounding central axis; periphery.

2. Branching of one of the filaments taken about three cells from the central cylinder. Shows somewhat regular branching, similar to the branching of the main axis. At the periphery dichotomous branching is illustrated.

3. A portion of the central axis showing a branch which is leaving it. Protoplasmic axis of the central cylinder. The protoplasm appears to separate into threads to pass through the thickened plate.

4. Longitudinal section of frond. Axis cylinder surrounded by mucilaginous sheath. This figure illustrates the point that the main branches from the axis cylinder do not run out radially, but diagonally upward, reaching the periphery opposite the lower end of the third cell of the central axis from which they started.

5. Cystocarp containing carpospores; filaments ramifying among he spores.

6. Carpospores and branching filaments.

7. Holdfast. *a*, horizontal branch; *b*, stipe; *c*, brown cellular substance developed beneath the holdfast; *d*, vertical branch.

8. Section showing tetragonidangia and paraphyses in different stages.

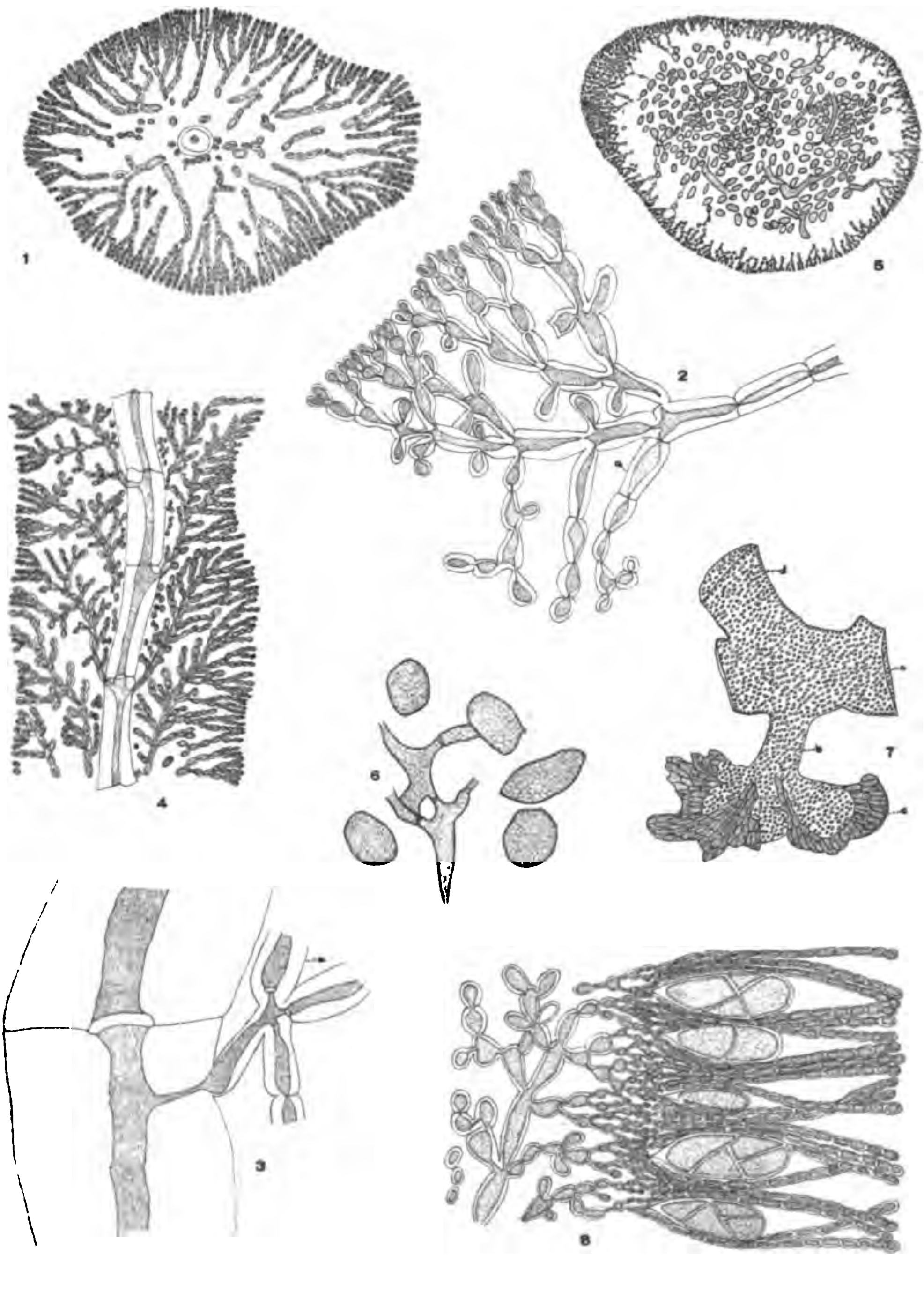

PLATE XLVI.

HELIOTYPE CO., BOSTON.

XXVI. OBSERVATIONS ON LAMINARIA BULLATA KJELLM.

Olga Mueller.

The plant, *Laminaria bullata*, was first studied by Kjellman in 1889 from material found by him in St. Lawrence Bay of St. Lawrence island in Behring Sea. Some of the material used for these observations was found by Miss Josephine Tilden at Tracyton, Washington, but the greater part was collected by the writer near Port Renfrew, on Vancouver island, on the straits of Juan de Fuca, in August, 1902. From this it appears that the plant has a wide distribution on the western coast of North America, extending from Alaska to Puget sound, and possibly to California.

The writer is deeply indebted to Professor Conway MacMillan and to Miss Josephine Tilden for helpful suggestions.

The plants collected at Port Renfrew were found growing attached to rocks in a narrow arm of the sea leading into a cave. Here the tidal currents were very strong, moving the plants constantly to and fro, and bringing to them the food and oxygen necessary for their life. They were found growing in the sublittoral zone and could be collected only at low tide and then with difficulty.

External Morphology.

The plant, like other members of the Laminariaceæ, consists of three portions; the holdfast, the stipe, and the lamina. The distinguishing feature of the plant is its rows of undulations, or of alternating elevations and depressions, called bullations, which run nearly parallel to the margin of the lamina, but at some distance from it. The color of the plant is dark brown. The margin of the lamina is straight and not undulated. Its texture is like that of strong, firm, sheet rubber, and its smooth glistening surface offers but little resistance to the action of the waves.

Plants of various ages were examined. The youngest was a tiny individual 2.5 cm. in length. The primitive disc showed to good advantage; its lower surface was almost flat, while the margin was slightly irregular, with indications of where the first hapteric branches would arise.

The stipe was .8 cm. long — cylindrical below and slightly flattened above where it merged into the lamina. The lamina was .17 cm. long, rather oblong in shape, showing as yet no traces of the bullations which are so characteristic of the older specimens, and the free end of the lamina even in so young a specimen was not perfect, but slightly notched and irregular — due no doubt to the action of the waves.

The largest specimen studied was found growing at Tracyton, in quiet water. Its length was 143 cm. and the greatest width of the lamina was 30 cm.

The holdfast by means of which the plant attached itself to the rocks on which it grew, consisted of a mass of dichotomously branched hapteres, which had arisen from above the primitive disc. These hapteres were brown in color, being of a lighter shade and of a more delicate texture towards the apex. In this largest specimen the stipe was unusually short, being but 2.5 cm. in length. Most of the specimens examined showed larger stipes, as in one whose lamina was 52 cm. long, the stipe had a length of 8 cm.

The stipe is strong and tough in texture. It retains the characteristic of the earlier stage of being cylindrical at the base and flattened where it merges into the lamina.

The laminæ of different specimens varied considerably in outline, some being almost oblong, others broad ovate and others elliptical.

The texture varies also, the laminæ of some plants being much thicker and firmer than of others. These differences of form and texture are due, no doubt, to differences in the intensity of the light, and the strength of the tidal currents.

The margins are in every case straight but the apex is almost always frayed and split. There is often one long split extending nearly to the base of the lamina, a second one not so deep, and several minor indentations besides. This splitting takes place in a direction parallel to the margin of the lamina and usually near the rows of bullations.

Although splitting seems to be the rule, yet our largest specimen showed scarcely a trace of it. This was no doubt due to the fact that it was found growing in quiet water. Its apex however was frayed somewhat by the action of the waves.

The region of growth is at the point where the stipe joins the lamina, and here, in the younger portion of the lamina, the bul-

lations are most perfect, being more greatly elevated and depressed, though not so large in diameter as in portions near the apex.

The plant is a perennial, and towards the older portion of the lamina the bullations become broader and more shallow until they finally disappear, leaving the older portion of the lamina with an even surface (*fig. 1*).

The greater part of the material was preserved in a five per cent. solution of formaline, a little alcoholic material was used. The former proved the more satisfactory. Free hand sections mounted in glycerine jelly were used for study.

ANATOMY.

Laminaria bullata, like the other members of the Laminariaceae consists of three tissues, viz., the epidermal, the cortical, and the pith. Only the first two are found in the hapteres, while the stipe and lamina contain them all.

The surface of the plant is covered by a thick structureless cuticle; below this are the epidermal cells, prismatic in form, about one and one-half times as long as broad, but with the two shorter diameters equal, so that when the cells are seen from the surface, they appear as cubes or pentagons.

These epidermal cells are densely crowded with chromatophores, their chlorophyll being masked by the brown coloring matter characteristic of the kelps. The outer wall is comparatively thick while the lateral and inner walls are rather thin.

Below the single layer of epidermal cells are found from two to four layers of cells which are shorter and broader than the epidermal cells, and not so densely crowded with chloroplasts. These are the hypodermal cells.

Next to the hypodermal cells are found the cortical cells, which are more irregular in form, though still prismatic. They increase in size towards the center of the plant, and are followed by strengthening cells which are smaller in diameter and longer than the cortical cells. They also have thicker walls and some of them are imbedded in the mucilaginous material of the central part of the plant. These cells are devoid of chromoplasts, but contain granular protoplasm.

The pith web consists of numerous colorless, interlacing and anastomosing hyphæ embedded in mucilage.

HAPTERE.

A longitudinal section of the haptere shows that it is composed of a layer of cuticle on its surface and below this are the prismatic epidermal cells with their numerous chromatophores. Next to these are two layers of hypodermal cells, and just within are the cells of the cortex. These are much larger and more irregular in form than the epidermal cells (*fig. 3*). In the center of the haptere are found rather thick walled elongated cells arranged in rows.

These rows run in a straight course to the apex of the haptere (*fig. 4*), while cells at the sides of the haptere bend in curving rows from the circumference towards the center (*figs. 5, 2*.) The cells near the end of each row have the power of dividing and it is here that the haptere increases in length and in thickness. Both cross and longitudinal sections reveal numerous circular openings in the hypodermis. These are the mucilage ducts which in the haptere seems to take the form of spherical pits. Faint traces of branches may sometimes be seen, so that it is possible that these pits are in communication with each other. Each pit is surrounded by little granular secreting cells.

There is no pith in the haptere, the thick-walled, elongated cells of the cortex occupying the interior of the haptere.

In the stipe is found much the same arrangement of tissues as in the haptere, but with this difference, that a pith web occupies a considerable portion of the interior of the stipe.

The lower cylindrical portion of the stipe is hollow with only traces of the pith web left. In the upper, younger, more flattened portion, the pith web fills the center of the stipe (*fig. 6, A, B*).

The cuticle is thicker on the surface of the stipe than on the haptere; the epidermal cells are slightly more elongated but otherwise much like those of the haptere (*fig. 9*). The hypodermal cells consist of several rows and among them are found the mucilage ducts. A cross section shows them to be large elliptical openings, very close together, in fact with only the bounding cells of each duct between. Each duct appears to have been formed as a fissure between four or five adjoining cells (*fig. 8*). These cells have very granular contents, are enlarged at the ends of the ducts but compressed where the ducts are broadest. The longitudinal section shows the ducts

as long cylindrical tubes — with the inner side crenate and the outer straight, and with the secreting cells very granular (*fig. 7*).

The cortex cells of the stipe are not so large as those of the haptere (*figs. 10, 11*). The strengthening cells found near the pith web, are in general cylindrical in form; the innermost are imbedded in mucilage. These cells are characterized by each possessing an unusually large nucleus. The granular protoplasm passes through the center of the cell and communicates with that of adjoining cells through the end partition walls.

The pith web is formed of interlacing, colorless hyphæ. In both cross and longitudinal sections can be seen some hyphæ which have been cut obliquely and others which have not been cut at all, showing that they run in various directions. The majority of them take a lengthwise course, however. The hyphæ (*figs. 12, 13*) have comparatively thick walls, are imbedded in mucilage and contain protoplasm and some starch grains. Trumpet hyphæ are numerous and are found running lengthwise more often than crosswise.

In the lamina we see again the same tissues as in the stipe. The chromoplasts of epidermal and hypodermal cells are more numerous than in the corresponding cells of the stipe. The mucilage ducts are not so numerous nor so compressed, being circular rather than elliptical in outline (*fig. 14*). The cells of the cortex are large and cuboidal in form (*fig. 14*) and following these are the thick-walled strengthening cells, circular or oval in cross section (*fig. 15*), and often arranged in pairs as though recently divided; elongated and of uniform diameter in longitudinal section (*fig. 16*). In these cells the hyphæ of the pith web take their origin, as branches from the sides of the cells, or as a prolongation of the cell proper (*figs. 15, 16*).

In some cases the hyphæ can be traced from their origin in one cell, across the pith web to their termination in another cell on the other side. The pith web is richly supplied with mucilage, and imbedded in this are numerous trumpet hyphæ — which do not differ from those of the stipe (*fig. 17*).

The bullations, which are so striking a feature of the plant, are not due to a thickening of any of the tissues of the lamina, but rather to a bending in and out of these tissues, the epidermis, cortex and pith web following each other in the same order and proportion as they do in the even portions of the lamina.

Material in the fruiting condition was not available, and therefore observations on the reproduction will be made at a future time. According to Kjellman the sori are found as oval areas spread over that portion of the lamina where the old lamina merges into the new. The sporangia do not differ from those of other Laminariaceæ.

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EXPLANATION OF PLATE XLVII.

1. Photograph of *Laminaria bullata.*

2. Diagram of haptere showing the direction taken by the cells of the cortex. They run in straight lines towards the apex of the haptere, but bend outward at the sides.

3. Longitudinal section of haptere showing epidermal cells, hypodermal cells, cortex and a mucilage duct.

4. Cells near apex of haptere, as seen in longitudinal section.

5. Cells from side of haptere showing curving direction of cortex cells. Longitudinal section.

6, *a.* Diagram of lower hollow portion of stipe.

b. Diagram of upper portion of stipe.

7. Diagram of longitudinal section of stipe. *a*, epidermal region; *b*, mucilage duct; *c*, cortex; *d*, strengthening cells; *e*, pith web.

8. Cross section stipe, showing cuticle, epidermal and hypodermal cells, mucilage ducts and cortex cells.

9. Epidermal and hypodermal cells of stipe. Longitudinal section.

10. Strengthening cells of cortex of stipe. Cross section.

11. Strengthening cells of cortex of stipe. Longitudinal section.

12. Pith web of stipe. Longitudinal section.

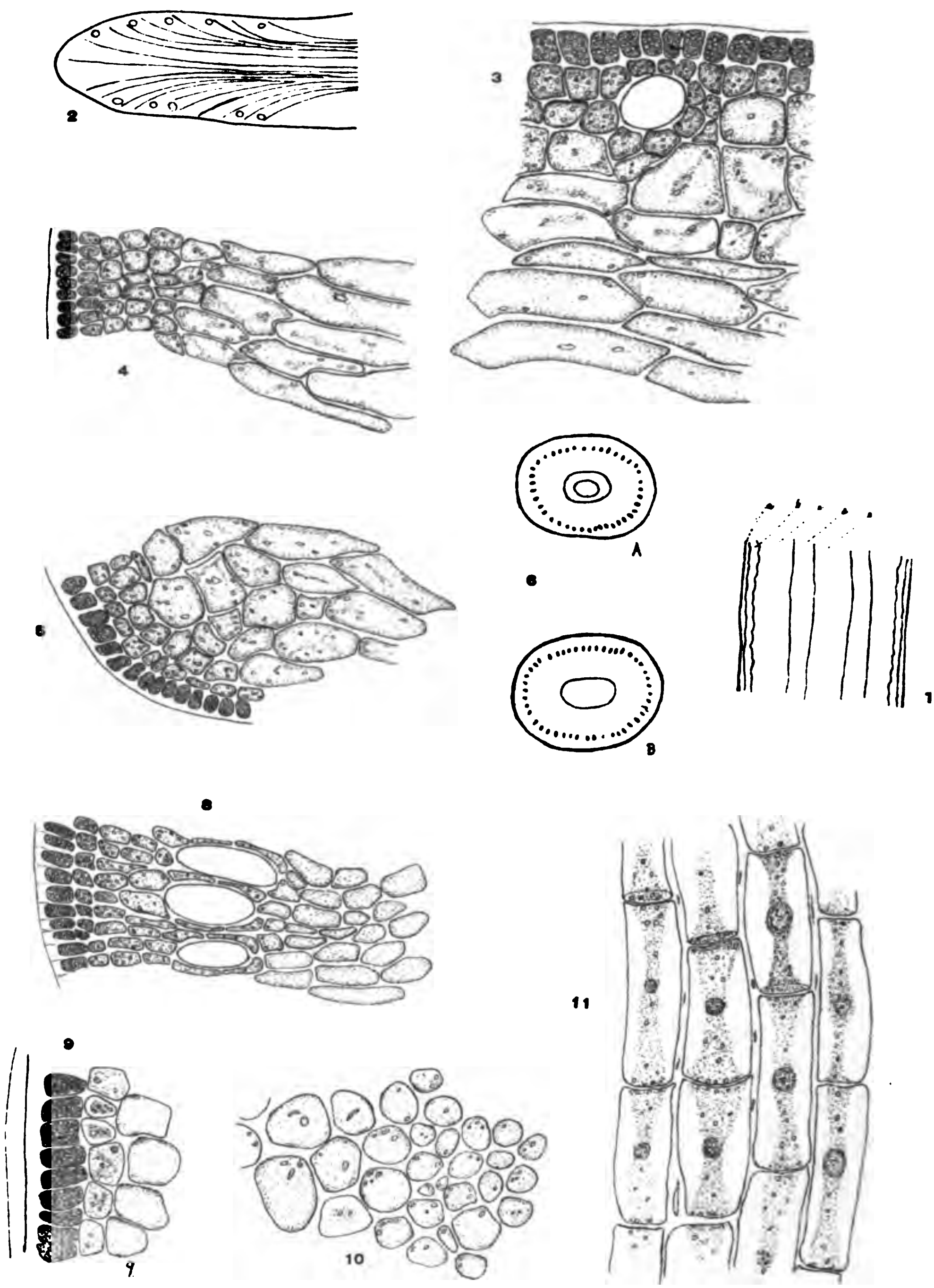
13. Pith web of stipe. Cross section.

14. Cross section of lamina showing cuticle, epidermal cells, hypodermal cells, mucilage duct and cortex cells.

15. Cross section of lamina showing strengthening cells and origin of hyphæ of pith web.

16. Longitudinal section of lamina showing same points as 15.

17. Pith web of lamina in longitudinal section.



PLATE

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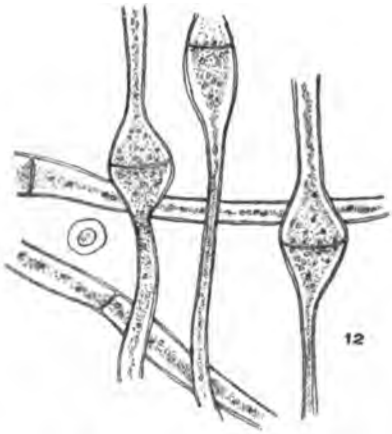

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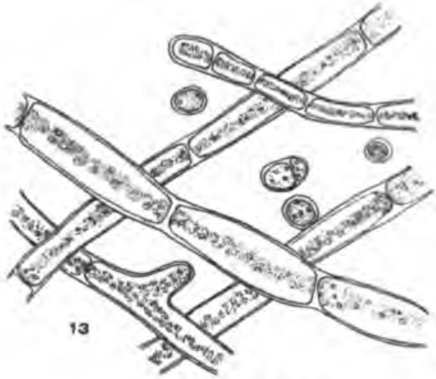

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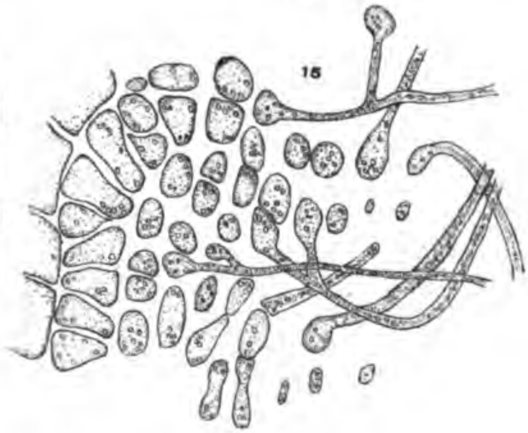

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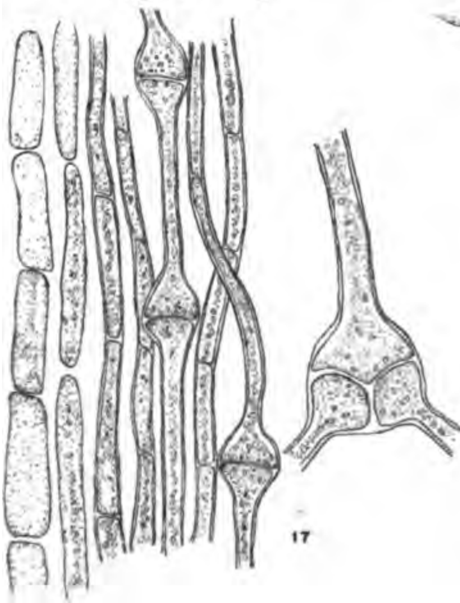

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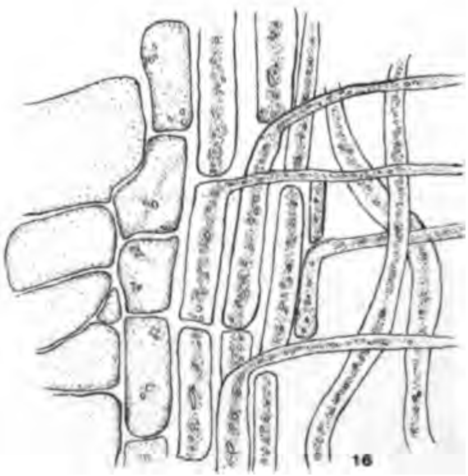

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XXVII. MINNESOTA HELVELLINEÆ.

Daisy S. Hone.

The following is a list of Minnesota Helvellineæ collected at various times since 1886.

In the determination of these species, Dr. H. Rehm's work has been carefully consulted, as have also among many others the British works of Phillips and Massee and the American papers of Peck and Morgan. These works have been used freely in the descriptions, though only where they agree with my observations on the Minnesota plants. Krombholz's plates have been compared and cited under each species. Comparisons have also been made with the Exsiccatæ in the University Herbarium and the results of such comparisons have been noted in each case. Schroeter's generic classification as outlined in Engler and Prantl, Die Naturlichen Pflanzenfamilien, has been closely followed.

All drawings were made with the aid of an Abbe camera lucida, usually from material preserved in formalin or from dried material soaked in water. In a few cases fresh material was used. The photographs were taken by Mr. C. J. Hibbard, photographer on the Minnesota Geological and Natural History Survey. All species, described are now in the collection of the Museum and Herbarium of the University. They are preserved in a mixture of two per cent. formaline and seventy per cent. alcohol and also in the dried condition.

Eight genera with fourteen species and two varieties here reported are from Minnesota. Five species belong to the Geoglossaceæ and nine to the Helvellaceæ. No member of the Rhizinaceæ has yet been reported, but the common species of *Rhizinia* probably occurs in the State. Specimens marked * are those from which the photographs have been taken. The reports of localities are given in counties.

I wish to express by thanks for the aid and supervision of Professor E. M. Freeman, of the University of Minnesota, under whose direction the work was done. I also wish to

HELVELLACEÆ.

thank Mr. C. J. Hibbard who kindly assisted by making the photographs.

1. **Helvella lacunosa** AFZEL, Act. Holm. 304. 1783. (*Plate II., figs. 11, 12, 13; Plate IV., figs. 11–16.*)

Solitary or gregarious; stipe lacunose, fistulose, slender, grayish to mouse-colored, up to 3.25 in. high, 1.25 in. wide; pileus saddle-shaped or three lobed, slightly wrinkled, mouse-colored, up to 2 in. in diameter; spores elliptical, obtuse, smooth, containing one large oil drop, 16–18 mic. long, 9–12 mic. wide; paraphyses filiform, branched, clavate, about 6 mic. wide at the tip.

On ground in moist, soft woods.

Ramsey, Sept. 1898, Freeman 229; Cass, Sept. 1898, Freeman, 186; *Hennepin, Oct. 1900, Butters 63; Hennepin, Sept. 1900, Freeman 760; Hennepin, Oct. 1900, Hibbard.

According to Phillips: "Differs from *H. crispa*, for a variety of which it may easily be taken, by the more regular pileus, 2–4-lobed, scarcely laciniate, lobes later becoming free, and especially by the colour. The stature generally smaller. Acute characters are wanting in nature, therefore it is constant." The stipe is more slender than that of *H. crispa*.

The specimens agree with Thuemen Mycoth. Univ. 809, spores of which are up to 16 × 12 mic.; Sydow Mycoth. March, 182, spores of which are 16–18 mic. × 8–10 mic.; Sydow Mycoth. March 2845, spores are 14–16 mic. × 8–10 mic.

Krombholz Schwämme III., *pl. 19, figs. 18–21* (*lacunosa*), *figs. 22–26* (*sulcata*); *pl. 21, figs. 22–24.* 1834.

2. **Helvella crispa** (SCOP.) FR. Syst. Myc. 2: 14. 1822. (*Plate II., fig. 10.*)

Generally solitary; stipe lacunated, fistulose, slightly bulbous at the base, stout, grayish, measures up to 4 in. high and 2 in. wide; pileus very much lobed and folded or wrinkled, white, up to 2.5 in. across; spores elliptical, obtuse, smooth, containing one very large oil drop, 10–16 mic. long by 8–10 mic. wide; paraphyses filiform, clavate, septate, branched, about 4 mic. wide at the tip.

On ground in hard woods, chiefly oak.

Hennepin, Oct. and Sept. 1900, Freeman 895, 734, 804; Becker, Aug. 1901, Freeman 1053; * Chisago, Sept. 1900, Butters 15; Ramsey, Sept. 1903, Cuzner; Ramsey, Sept. 1903, Wilcockson.

H. crispa is closely related to *H. lacunosa;* for differences see *H. lacunosa.*

The specimens agree with Sydow Mycoth. March 181, spores of which measure up to 12 mic. × 16 mic.

Krombholz Schwämme III., *pl. 19, fig. 27–29.* 1834.

3. **Helvella elastica** BULL. Champ. franc. 299, *pl. 242.* 1785. (*Plate II., figs. 14, 15.*)

Stipe cylindrical, not lacunated, hollow, smooth, or pruinose, grayish, up to 2.25 in. high by 1 in. across; pileus saddle-shaped, bilobed, mouse-colored above, grayish beneath, up to 1.25 in. across; spores elliptical, obtuse, smooth, containing one large, central oil drop, up to 16–20 mic. long by 10–12 mic. wide; paraphyses filiform, septate, branched, clavate, about 6 mic. wide at the tip.

On ground in moist places and among grass.

* Hennepin, Sept. 1900, Freeman 877; Hennepin, Oct. 1900, Butters 66; Becker, Aug. 1901, Freeman 1040; Cook, Aug. 1903, Freeman and Ballard 3.

The specimens agree with *D. Saccardo* Myco. Ital., spores of which average 14 mic. × 9 mic.

Krombholz Schwämme III., *pl. 21, fig. 21,* 1834.

4. **Helvella infula** SCHÄFFER, Icon. Fungi, *pl. 159.* 1763. (*Plate II., figs. 1, 2, 3; Plate IV., figs. 24–29.*)

Gregarious or solitary; small or large; stipe cylindrical, tapering toward top, at first solid later hollow, cream to flesh-colored, densely pubescent at the base, up to 2.25 in. high by 1 in. wide; pileus more or less saddle-shaped or irregularly undulated, margin attached in places to the stipe, yellow to cinnamon brown or chestnut brown above, cream to flesh-colored beneath, finely pubescent beneath, up to 2.25 in. deep; spores elliptical, obtuse, smooth, with two equal oil drops, 18–24 mic. by 8–12 mic.; paraphyses clavate, septate, branched, brownish, about 4 mic. wide.

On the ground along paths and trails or among moss. It usually prefers clayey ground but occasionally is found even on decayed logs.

* Cook, Aug., 1902, Fink; Cook, Aug., 1903, Freeman and Ballard 5.

This is *Gyromitra infula* (Schäff.) Buel. Schröter in Die Naturlichen Pflanzenfamilien, has defined *Gyromitra* as possessing an inflated cap. In the above species no true inflation of the cap is found, *i. e.*, the cavity of the stipe is not prolonged into a cavity in the cap as in the morels. Hence the condition here is similar to that of *Helvella*. It approaches the true *Gyromitras* however in the tendency of the cap to become irregularly convoluted and especially in the fusion of the cap with the stipe. *Helvella infula* Schäff. therefore stands between the *Gyromitras* with truly inflated cap and the typical *Helvellas* without fusion of cap and stipe. There is moreover often a very marked saddle form to specimens of this species. Schröter's conception of the genus *Gyromitra* accords with Fries' original description "discus bullato-inflatus, costis elavatis gyrosus." (Summa Veg. Scand. 346. 1849.)

Our specimens agree with Krombholz Schwämme III., *pl. 19, figs. 11–13* (*H. rhodopoda* which is clearly a true *Helvella* and is included by Rehm as a synonym under *H. infula*. They also agree with Roumeguere Fungi Gall. Exsicc. 1208, in which the spores measure 18–22 mic. × 9–12 mic.; Krombholz Schwämme III., *pl. 21, figs. 12–17*. *Helvella infula* also agrees as far as exterior views are concerned but the sectional views do not clearly show the relation of stipe and cap cavities as seen in the Minnesota specimens.

Certain specimens of these *Helvellas* contained an abundance of *Sphæronæmella helvellæ* Karst. It differs from Karsten's descriptions (Hedw. **23**; 18. 1884) in its possession of ultimately uniseptate spores. These are at first continuous and later uniseptate. In all other points the agreement is complete.

5. **Verpa conica** (Mill.) Swartz. Vet. Ak. Handl. 136. 1815. (*Plate II., figs. 4, 5, 6; Plate IV., figs. 30–33.*)

Stipe cylindrical, tapering at the apex, hollow, white, even or slightly wrinkled, floccose, up to 2.5 in. high and 1.5 in. wide; pileus conical, even or slightly wrinkled, brownish above, white beneath, up to .5 in. deep by 1 in. across at the base; spores elliptical, obtuse, smooth, containing one large central oil drop, 20–22 mic. long by 10–14 mic. wide; paraphyses filiform, septate, branched, 6 mic. wide.

On moist ground.

Ramsey, May 1899, Freeman 313; * Wright, May 1900, Freeman 588; Beltrami, May 1902, L. R. B. W. 52; Ramsey, May 1903, Polley; Hennepin, May 1903, Ramsey and Hone; Chisago, May 1903, Nelson.

The specimens agree with Sydow Mycoth. March 3166, of which the average spore measures 20 mic. × 12 mic.; Roumeguere Fungi Selecti Exsicc. No. 4554, of which the average spore measures 20–22 mic. × 12–14 mic.

Krombholz Schwämme III., *pl. 5, figs. 29–31.* 1834.

6. **Verpa bohemica** (KROMBH.) SCHRÖT. Schles. Krypt 3^2: 25. 1893. (*Plate II., figs. 7, 8, 9; Plate IV., figs. 17–23.*)

Stipe cylindrical, stuffed or hollow, floccose, white, even, not wrinkled, up to 4 in. high by 1 in. across; pileus conical obtuse, reticulated or longitudinally ribbed, edge sometimes inflexed so as to form a white border, brownish above and white beneath, up to 1.25 in. deep; spores elliptical, obtuse, straight, or bent, one-celled, hyaline, only two in an ascus, up to 60 mic. long by 16 mic. wide; paraphyses filiform, branched, septate, up to 4 mic. wide at the tip.

On damp ground, often among broken limestone.

* Hennepin, May 1899, Freeman 302; Hennepin, April 1901, Lyon; Hennepin, April 1903, Butters and Ramsey; Ramsey, May 1903, Polley.

Verpa bohemica is easily distinguished by the two large spores in each ascus.

The specimens agree with Rathay Fl. Exsicc. Austro-Hung. No. 1573, of which the spores measure 60 × 14 mic.; Thuemen Mycoth. Univ. 609, of which the spores measure 60–80 mic. × 16–18 mic.

Krombholz Schwämme III., *pl. 15, figs. 1–13.* 1834.

7. **Morchella hybrida** (SON.) PERS. Syn. Meth. Fungi. 620. 1801. *Plate I., figs. 7, 8; Plate IV., figs. 8–11.*

Stipe cylindrical, bulbous at base, tapering toward apex, whitish, granulose, 1–6 in. high: pileus brownish to tan, conical, acute, lower half free from stipe, longitudinally pitted and ribbed, about 1.5 in. deep; spores elliptical, obtuse, smooth, hyaline, 18–20 mic. long by 10–14 mic. wide; paraphyses slightly clavate, vacuolated, septate, branched, about 12 mic. wide at the tip.

On ground in shady places, sometimes in gravel and also along roadsides.

* Hennepin, May 1902, Butters 201; * Hennepin, May 1903, Polley; * Ramsey, May 1903, Freeman; Hennepin, May 1903, Lyon and Rosendahl.

Morgan states (Morchellæ—The Morels, Journ. Myc., Vol. VIII., June, 1902) that no paraphyses are present in *M. hybrida* or in *M. esculenta*. *M. hybrida* as generally accepted however has paraphyses. They are large and are therefore easily mistaken for young asci, but are septate and sometimes branched. Collections marked with a * contain small forms, one inch high or less.

The specimens agree with Thuemen Mycoth. Univ. No. 412, the spores of which measure 20–24 mic. × 14 mic.; Ellis and Everhart N. A. Fungi No. 2628, the spores of which measure 20–22 mic. × 12–14 mic.

Krombholz Schwämme III., *pl. 15, figs. 14–21.* 1834.

8. **Morchella esculenta** (L.) PERS. Syn. Fungi. 618. 1801. (*Plate I., figs. 3–9; Plate IV., figs. 1–6.*)

Solitary or gregarious; stipe cylindrical, hollow, sometimes bulbous, granulose or glabrous, white, entire, .5 to 2 in. high by .5 to 1 in. thick; pileus is very varied from conical to obtuse, irregularly or longitudinally pitted, olive brown to grayish brown; ribs of the pileus are thick and obtuse at the edge; the surface being even, pileus is about 2.5 in. long; spores are elliptical, obtuse, smooth, one large oil drop in center, sometimes yellowish, 14–22 mic. long by 8–14 mic. wide; paraphyses filiform, clavate, septate, branched, in some specimens very abundant.

On the ground in shady woods. Very common in oak woods.

* Hennepin, May 1891, Sheldon 20; Wright, May 1900, Freeman 675; Hennepin, May 1901, Polley; Hennepin, May 1903, Rosendahl; Wright, May 1903, Polley; *Hennepin, May 1903, Hone 218; * Hennepin, May 1903, Polley.

Like *M. hybrida*, *M. esculenta* is generally accepted as having paraphyses. The above cited material certainly possesses structures which resemble paraphyses in all essentials. They are septate, often branched, and are smaller than the asci, growing among the latter in the hymenium. The collections marked with a * have rather conical caps and the ribs are longitudinal and regular. In all other characteristics they are true esculenta forms and I have no doubt that these two collections contain the forms which have been described as *M. conica*. As

M. esculenta occurs in such varied sizes and forms in all of the material which I have examined, I consider that if these are *M. conica*, that they are only a form or variety of *M. esculenta* and not a distinct species. *Plate I., figs. 3–6*, show photographs of both forms.

The specimens agree with Thuemen Fungi Austr. 12, 13, where the spores measure 14–22 mic. × 6–12 mic (12 contains paraphyses measuring 10 mic. at tip and branched); Rathay Fl. Exsicc. Austro-Hung. 1572, in which the spores measure 20 × 12 mic.; D. Saccardo Mycoth, Italica, 507, in which the spores measure 14–18 × 10–12 mic.

Krombholz Schwämme III., *pl. 16, figs. 3, 4* (Morch. escul. rotunda Fr.), *5, 6* (Morch. escul. vulgaris F.), *pl. 17, figs. 3–4* (Morch. escul. fulva Fr.), *9–16; pl. 19, figs. 6–7*.

9. **Morchella crassipes** (VENT.) PERS. Syn. Meth. Fungi 620. 1801. (*Plate I., figs. 1, 2; Plate IV., fig. 7.*)

Solitary or gregarious; stipe cylindrical, hollow, bulbous, very much furrowed, granulose, white, .5–4.5 in. long by .75–1.75 in. wide; pileus conical or subconical, ribs very irregular, undulating, thick, acute at the edge, pits deep, surface very ragged and uneven, yellowish, 1.5–3 in. deep; spores elliptical. obtuse, smooth, one large central oil drop, 20–22 mic. long by 10–12 mic. wide; paraphyses broad, as wide as the asci, septate and vacuolated, 10–18 mic. wide.

On ground in most shady woods or open places.

LeSueur, June 1891, Taylor 49; Ramsey, June 1899, Freeman 359; Hennepin, May 1899, Buell; Hennepin, May 1901, Freeman 1000¾; * Hennepin, May 1903, Hone 217.

M. crassipes differs from *M. esculenta* in its greater size, up to 7.5 in. high, yellowish color and very uneven surface. The ribs also are very acute at the edge and thick at the base while in *M. esculenta* they are even and very obtuse at the edge.

Krombholz Schwämme III., *pl. 16, figs. 1–2*. 1834.

GEOGLOSSACEÆ.

10. **Spathularia clavata** (SCHAEFF.) SACC. Michelia 2: 77. 1880. (*Plate III., fig. 1; Plate V., figs. 13–15, 20.*)

Gregarious; stipe cylindrical slightly compressed, hollow, erect, single or cæspitose, fleshy, yellowish brown, up to 3 in. long by .5 in. wide; pileus spatulate or broadly clavate, gen-

erally obtuse, much compressed, running down the stipe for some distance on opposite sides, hollow, glabrous, margin undulated, surface wavy or slightly lacunose, yellowish, up to 1.25 in. wide by 1.5 in. long; spores parallel in fascicles, hyaline, linear-clavate, slightly bent, multiseptate, containing small oil drops, up to 45 mic. long by 2 mic. wide; paraphyses filiform, septate, branched, tips not thickened but wavy, up to 2 mic. wide, numerous.

On rotten wood among moss.

St. Louis, July 1886, Arthur 194; * Cook, Aug. 1903, Freeman and Ballard 20.

These specimens agree with Thuemen Fungi Austr. 925, in which the spores measure up to 50 mic. × 2 mic.; Sydow Mycoth. March 2516, in which the spores measure 45–60 mic. × 2 mic.; A. Kerner Fl. Exsicc. Austro-Hung. 1874, in which the spores measure 40–50 mic.; Ellis N. A. Fungi 1268, in which the spores measure 40–60 mic. × 2 mic.

Krombholz Schwämme III., *pl. 5, fig. 22.* 1834.

11. **Geoglossum hirsutum** Pers. Comm. Schaff. Icon. Fungi Bav. 37. 1800. (*Plate III., fig. 5; Plate V., figs. 1–4.*)

Cæspitose, erect, black: stipe cylindrical, solid, even, black, hirsute, up to 2.25 in. long by 1 in. wide; pileus club shaped, compressed or plicate, distinct from stipe, hirsute, up to 1 in. long and .75 in. wide; spores linear, slightly curved, septate into about 16 cells, multiguttulate, brown, obtuse, 100–120 mic. long by 4–7 mic. wide; paraphyses filiform, septate, curved or arched at the tip, much enlarged, brownish, 3 mic. wide, tip 4–6 mic. wide; setæ rigid, simple, brown or black, intermingled with the asci, sometimes twice as long as the asci, projecting beyond.

On moist ground among grass.

* Washington, July and Sept. 1903, Lyon; Washington, July 1903, Wheeler.

The specimens agree with Jaczewski, Komarov, Franzchel. Fungi Rossiæ Exsicc. 245, in which the spores measure 100–135 × 4 mic.; Sydow Mycoth. March 1069, in which the spores measure 100–120 × 4 mic.

They agree with the figures and description of Massee, Monograph of Geoglossaceæ, Ann. Bot., Vol. 11, *Pl. XIII., figs. 78, 79*; *Pl. XII., figs. 31, 31, a, 32.* 1897; Krombholz Schwämme III., *Pl. 5, figs. 20–21.* 1834.

Geoglossum hirsutum americanum COOKE, Mycogr. 3. *fig.* 1875.

Hymenium appears glabrous when examined under a hand lens as the setæ project but slightly beyond the asci; spores light brown and only 7–10 septate. It agrees with *G. hirsutum* in all other characters.

On ground among moss in an alder swamp.

Sherburne, Aug. 1901, Polley.

12. **Leptoglossum luteum** (PK.) SACC. Syll. Fungi **8**: 48. 1889. (*Plate III., fig. 2; Plate V., figs. 16–19.*)

Stipe cylindrical, minutely scaly, whitish, stuffed, even, up to 1 in. high; pileus club shaped, slightly compressed, grooved on one side, yellowish, smooth, up to .5 in. high; spores oblong, slightly curved, hyaline, obtuse, 28–38 mic. long by 5–6 mic. wide (most of the spores were immature but some show distinct indications of septations); paraphyses filiform, clavate, curved at the tip, branched, numerous, about 2 mic. wide.

On ground in swamp.

* St. Louis, July, 1886, Arthur 195.

The specimens agree with a specimen of unknown origin No. 82 collected at Kirkville, N. Y., June, 1889, the spores of which measure 26–34 × 4–5 mic. and each cell often contains one large oil drop.

They agree with the plates and descriptions of Peck, Rep. N. Y. St. Mus. Nat. Hist. **24**: 94, pl. 3, *figs. 20–24.* 1872 and Massee Monograph of Geoglossaceæ, Ann. Bot., Vol. 11, *pl. XII., figs. 28, 29, 30.* 1897.

13. **Leotia lubrica** (SCOP.) PERS. Syn. Meth. Fungi 613. 1801. (*Plate III., fig. 4; Plate V., figs. 5–8*).

Gregarious, cæspitose, usually gelatinous especially when old; stipe cylindrical or inflated at the base, compressed and often bent, hollow or pulpy within, pruinose, yellowish to greenish, up to 2 in. long by .5 in. wide; pileus irregularly hemispherical, inflated, wavy margin obtuse and folded, yellow to yellowish olive-green and very dark green, up to 1 in. across; spores elliptical slightly acute, straight or bent, smooth, with several large oil drops, when mature 2–4-celled, colorless or slightly greenish, often in two rows, 4–5 mic. wide by 18–22 mic. long; paraphyses filiform, septate, branched, slightly clavate, hyaline or greenish, up to 2 mic. wide, 4 mic. wide at tip.

On ground in woods often among moss. Usually on sandy soil.

Hennepin, July 1903, C. C. Conser; Washington, Aug. 1903, Wheeler; Ramsey, Sept. 1903, Freeman 1380.

The collection 1380 Freeman agrees in color and form with *L. chlorocephala*. The stipe is green and only slightly lighter than the cap and the plants are more slender. As many gradations may be found between this and typical *L. lubrica* forms so all of the above specimens have been listed under *L. lubrica*. The dried material from collection 1380 Freeman shows a yellowish stipe.

The specimens agree with Thuemen Fungi Austr. 517, the average spores of which measure 20 × 5 mic.; Sydow Mycoth. March 278, 667, the average spores of which measure 20 × 4 mic.; Thumen Mycoth. Univ. 1112, the average spores of which measure 18–20 mic. × 4–5 mic.

They agree with the descriptions and figures of Rehm Krypt. Fl. Vol. I. 1161. *fig. 1–4.* 1896 and of Massee Monograph of Geoglossaceae, Ann. Bot., Vol. 11, *pl. XIII., figs. 61, 65.* 1897.

14. **Cudonia circinans** (Pers.) Fr. Summa Veg. Scand. 348. 1849. (*Plate III., fig. 3; Plate V., figs. 9–12*).

Gregarious, erect, somewhat cæspitose; stipe fistulose or solid, even, twisted, expanding upward with the pileus, granulose or powdery, darker colored than pileus, up to 2 in. long, .25 in. across; pileus fleshy, convex and undulated, margin free, involute, variable in color with age, tan to dingy yellow, sometimes flesh tinted, up to .5 in. broad; spores linear, multiseptate, often containing several small oil drops in each cell, hyaline, curved slightly when free, obtuse, 35–50 mic. long by 2 mic. wide; paraphyses filiform, branched, septate, tip not enlarged but curved, up to 2 mic. wide.

On decayed log in deep balsam fir woods.

* Cook, Aug. 1903, Freeman and Ballard 131.

The specimens agree with Thuemen Mycoth. Univ. 1809, the spores of which measure 35–45 × 2 mic.; Ellis and Everhart N.A. Fungi 3533, the spores of which measure 35–40 × 2 mic.; D. Saccardo Mycoth. Italica 873, the spores of which measure 35–45 × 2 mic.

They also agree with the descriptions and figures of Rehm Raben. Krypt. Fl. Vol. I., 1163, *fig. 1–4.* 1896 and Massee

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Explanation of Plates.

All figures of plates are natural size.

Plate XLVIII.

Figures 1, 2. *Morchella crassipes.*
Figures 3, 4. *Morchella esculenta.*
Figures 5, 6. *Morchella esculenta* form *conica.*
Figures 7, 8. *Morchella hybrida.*

Plate XLIX.

Figures 1, 2, 3. *Helvella infula.*
Figures 4, 5, 6. *Verpa conica.*
Figures 7, 8, 9. *Verpa bohemica.*
Figure 10. *Helvella crispa.*
Figures 11, 12, 13. *Helvella lacunosa.*
Figures 14, 15. *Helvella elastica.*
Figure 16. See paper by Miss Jessie Polley on *Physalacria.*

Plate L.

Figure 1. *Spathularia clavata.*
Figure 2. *Leptoglossum luteum.*
Figure 3. *Cudonia circinans.*
Figure 4. *Leotia lubrica.*
Figure 5. *Geoglossum hirsutum.*

Plate LI.

Figures 1–6. *Morchella esculenta.*
Figure 1. Longitudinal section ½ nat. size.
Figure 2. Ascus, × 195.
Figure 3. Ascus with sixteen spores, × 195.
Figure 4. Spores, × 387.
Figure 5. Apex of an open ascus, × 387.
Figure 6, *a*. Normal mature paraphyses, × 195.
Figure 6, *b*. Young paraphyses, × 195.
Figure 7. *Morchella crassipes*, longitudinal section, ½ nat. size.
Figures 8–11. *Morchella hybrida.*
Figure 8. Longitudinal section, ½ nat. size.
Figure 9. Ascus, × 195.
Figure 10. Spore, × 387.
Figure 11. Paraphyses, × 195.
Figures 12–16. *Helvella lacunosa.*
Figure 12. Cross section of stipe, ½ nat. size.
Figure 13. Paraphyses, × 195.
Figure 14. Ascus, × 195.

Figure 15. Young ascus, × 195.
Figure 16. Spores, × 387.
Figures 17–23. *Verpa bohemica.*
Figure 17. Two asci, one emptied of spores, × 195.
Figure 18. Ascus, × 195.
Figure 19. Paraphyses, × 195.
Figure 20. Young paraphyses, × 195.
Figure 21. Longitudinal section, ½ nat. size.
Figure 22. Spores, × 387.
Figure 23. Open ends of asci, × 195.
Figures 24–29. *Helvella infula.*
Figure 24. Longitudinal section, ½ nat. size.
Figures 25, 26. Paraphyses, × 195.
Figure 27. Spores, × 387.
Figures 28, 29. Asci, × 195.
Figures 30–33. *Verpa conica.*
Figure 30. Longitudinal section, ½ nat. size.
Figure 31. Ascus, × 195.
Figure 32. Spores, × 387.
Figure 33. Paraphyses, × 195.

Plate LII.

Figures 1–4. *Geoglossum hirsutum.*
Figure 1. Spore, × 387.
Figure 2. Ascus, × 195.
Figure 3. Hair, × 387.
Figure 4. Paraphyses, × 195.
Figures 5–8. *Leotia lubrica.*
Figure 5. Longitudinal section, ½ nat. size.
Figure 6. Ascus, × 387.
Figure 7. Spores, × 387.
Figure 8. Paraphyses, × 387.
Figures 9–12. *Cudonia circinans.*
Figure 9. Longitudinal section, ½ nat. size.
Figure 10. Ascus, × 387.
Figure 11. Spores, × 387.
Figure 12. Paraphyses, × 387.
Figures 13–15, 20. *Spathularia clavata.*
Figure 13. Longitudinal section, ½ nat. size.
Figure 14. Ascus, × 387.
Figure 15. Spores, × 387.

PLATE

HELIOTYPE

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4

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E XLVIII.

CO., BOSTON.

PLATE

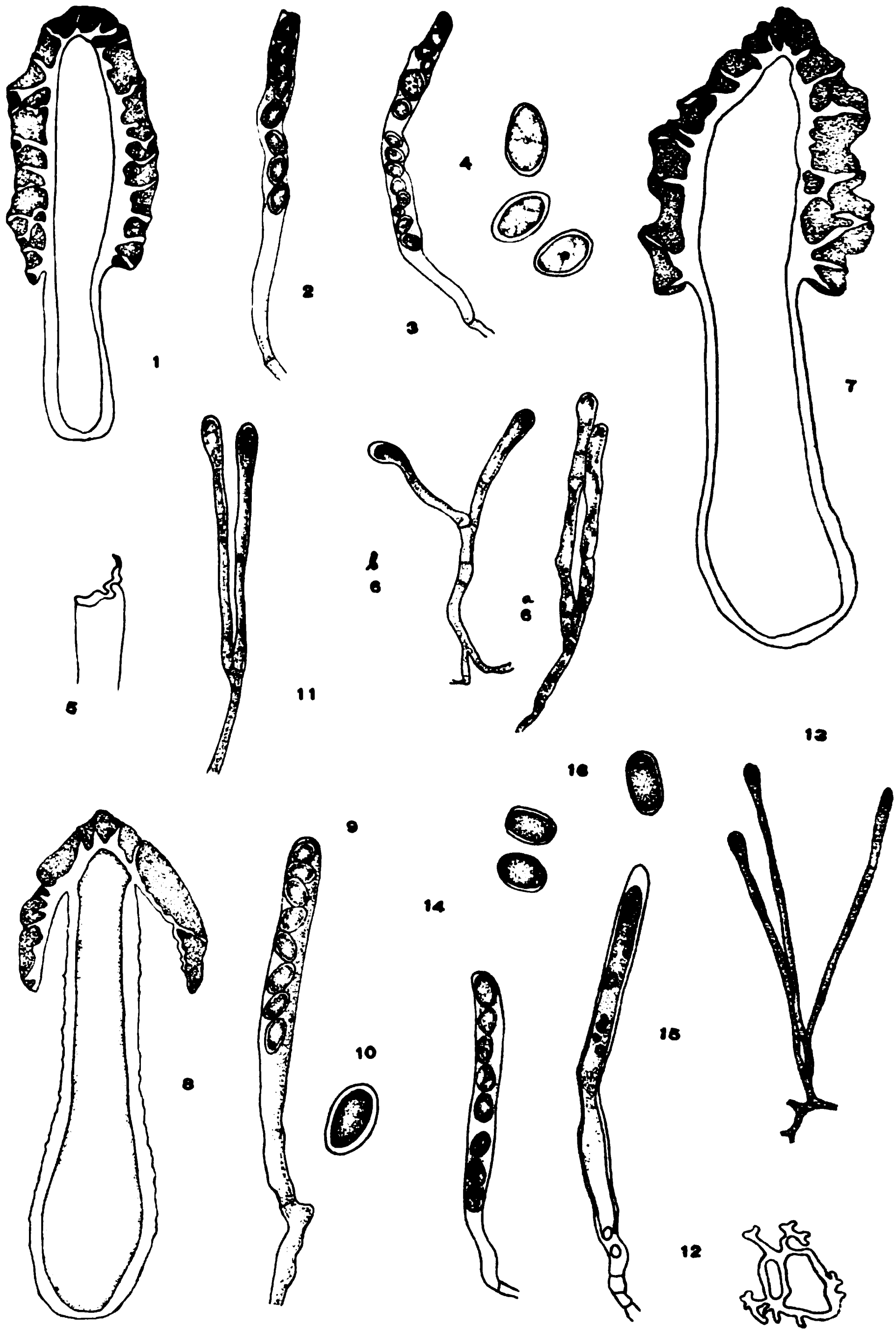
HELIOTYPE C

XLIX.

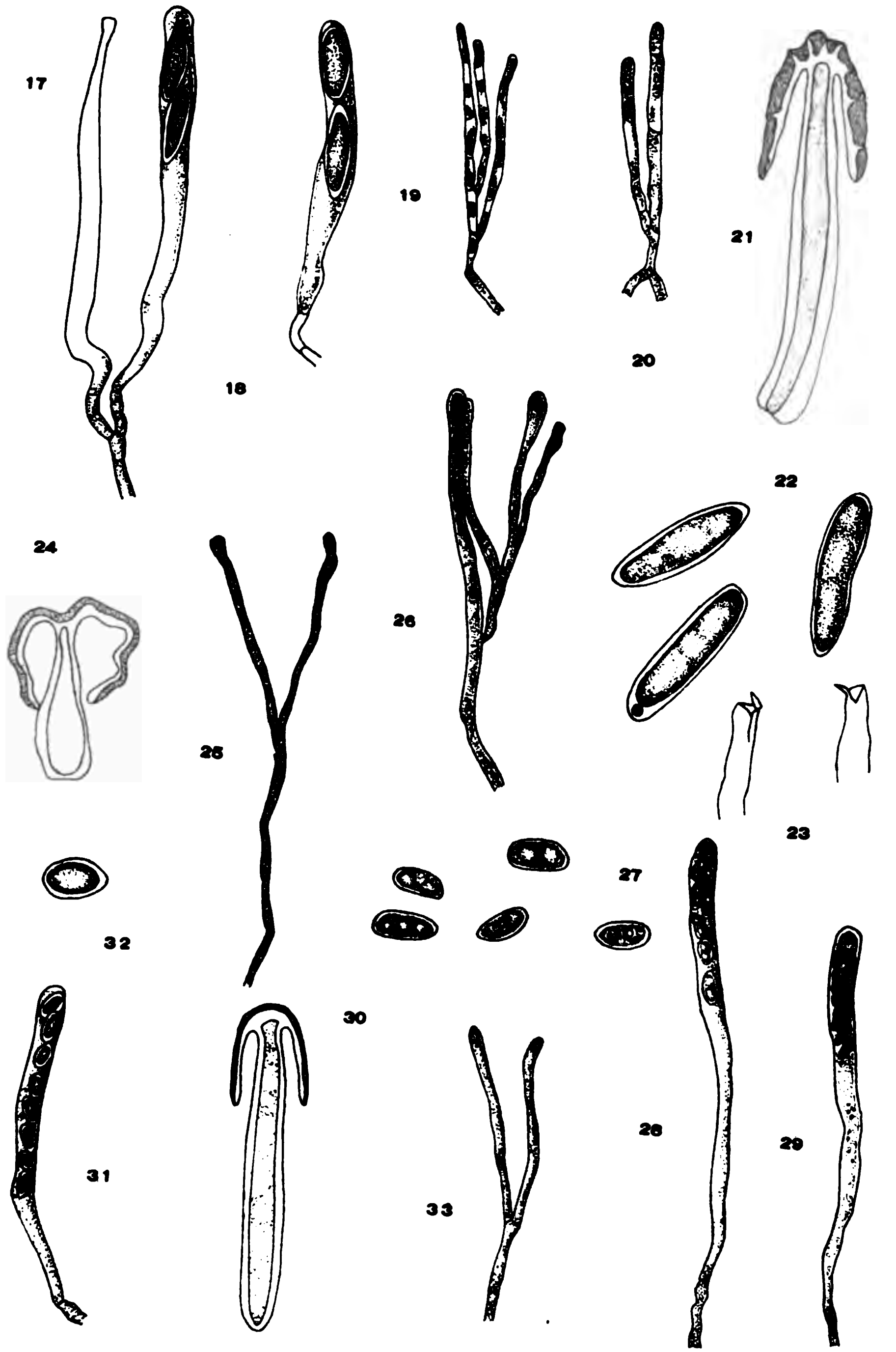
.D., BOSTON.

PLATE L.

HELIOTYPE CO., BOSTON.



HELIOTYPE R.



E LI.

., BOSTON.

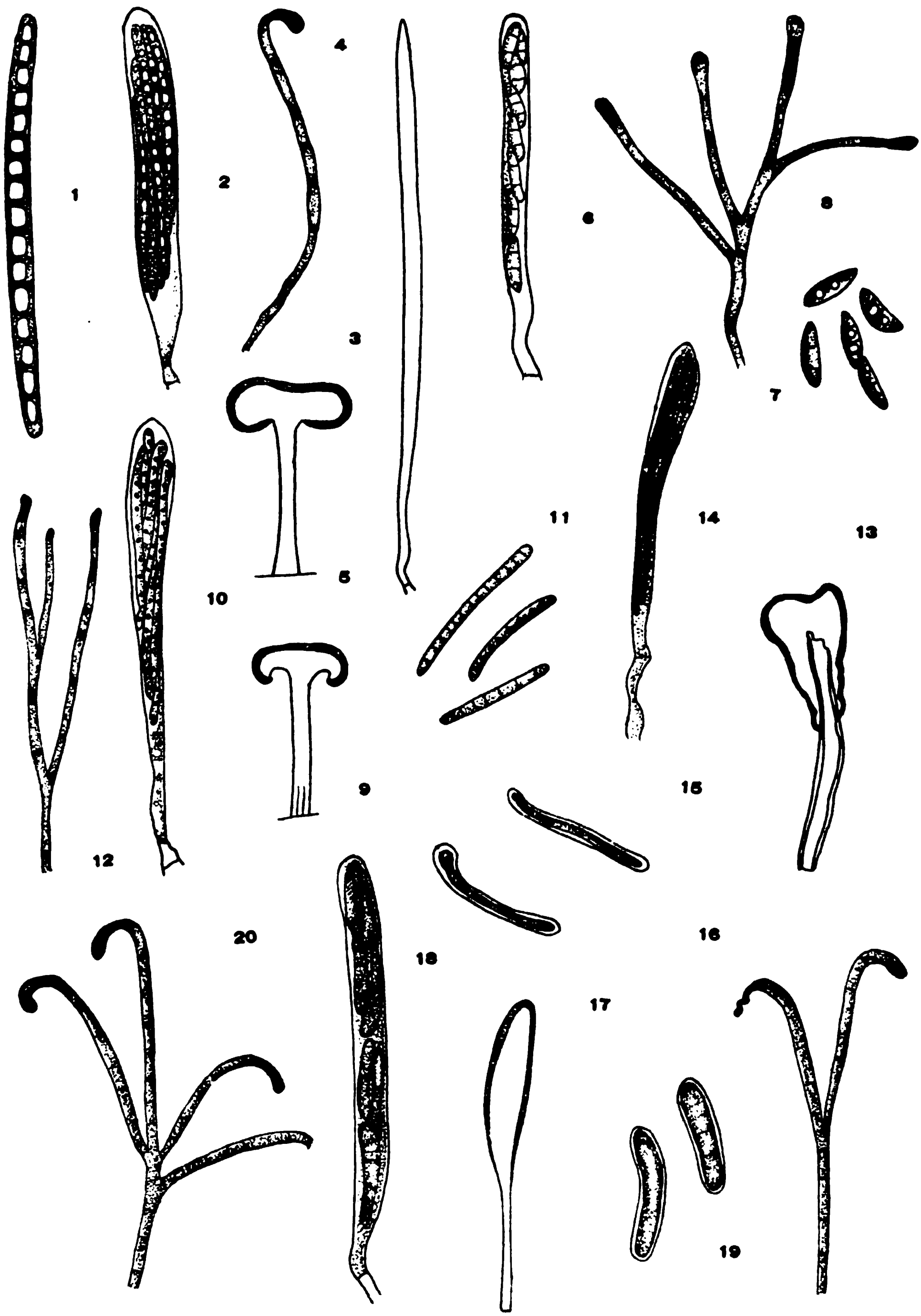


PLATE LII.

HELIOTYPE CO., BOSTON.

O

XXVIII. OBSERVATIONS ON PHYSALACRIA INFLATA (S.) PECK.

JESSIE M. POLLEY.

This rather rare and interesting club fungus was first described by Schweinitz in 1822, under the name of *Leotia inflata* (1). In 1828 Fries described it as *Mitrula inflata* (2), and it was again described by Cooke in 1879 as *Spathularia inflata* (3).

The first accurate description however, and the first appreciation of the true position of this fungus, was given by Peck (11) in 1882. His description is as follows:

"**Physalacria** gen. nov.

("From *φυσαχις*, a bladder and *αχρα*, the top.)

"Club subglobose, inflated, thin, somewhat tenacious, everywhere covered by the hymenium, supported on a distinct, slender stem.

"Distinguished from *Pistillaria* by the thin, inflated bladder-like club and the distinct slender stem. The following is at present the only species known:

"PHYSALACRIA INFLATA.

"White, becoming tinged with yellow; club subglobose, submembranaceous, glabrous, flaccid, more or less uneven with irregular depressions or wrinkles, two to four lines broad; stem slender, equal, firm, straight, solid, four to nine lines high, minutely hairy or subfurfuraceous, mostly cespitose; spores minute, narrowly elliptical, colorless, .00016–.0002 of an inch long and about half as broad.

"Decaying wood and bark in woods and shaded places. It occurs especially in mountains or hilly districts in summer."

Two years later Farlow (8) collected a few specimens in the White Mountains and identified them with Peck's description. His account is as follows:

"PHYSALACRIA INFLATA (S.) Peck.

"On logs in wet places. Shelburne, a small number of specimens of this curious species were found on a log in a brook which was nearly dry. My specimens were in fruit and I am able to confirm the account of the fructification given by Peck in Bull. Torr. Bot. Club, Jan. 1882. The species does not belong to the genus *Mitrula* where it was placed by Schweinitz, but it is one of the Hymenomycetes, closely related to *Pistillaria*, as correctly shown by Peck. I could find only two spores to a basidium."

The material from which the present description is written was collected by E. M. Freeman at Detroit, Minn., in August, 1901. A part of the material used had been preserved in $2\frac{1}{2}$ per cent. formaline and the rest had been dried. Permanent slides were prepared by the ordinary paraffin section method and gentian violet and bismark brown were employed in staining. The sections from which the greater part of the work was done were cut with an ether freezing microtome and mounted in water or in glycerine. All detail drawings were made with the aid of an Abbe camera lucida.

The plant grows upon decaying wood in shaded places or in deep woods, though it seems not to need as much moisture as many of the club-fungi. It grows in clusters and is $\frac{3}{8}$ to $\frac{5}{8}$ in. in height. Stem $\frac{1}{20}$ and club $\frac{1}{2}$ inch thick (Pl. XLIX., fig. 16). Many stipes come up together and diverge toward the top. The plants spread apart by the enlargement of the clubs which fuse on the sides where they press against each other. In general appearance they simulate some of the ascomycetes of the Geoglossacæ, *e. g.*, *Spathularia* and *Mitrula*, which led to the assignment of this species under those genera by earlier authors. They are creamy white in color except the base of the stem which is black.

Peck's description is very apt. In addition to the characters pointed out by him, the following are worthy of note. The stem is tough, at least in formaline material, and the central portion is more stringy than the peripheral region, this central portion is composed of two distinct kinds of hyphæ, small even threads with septa far apart (*figs. 7, 12*) and larger hyphæ which are composed of flasked-shaped cells set end to end. Both kinds of hyphæ are very rarely branched and lie parallel. In

cross section all of the cells appear circular and the largest are 11 μ in diameter and four or five times as large as the smallest ones. The latter are 2.5 to 4 μ in diameter and are probably stereome in function, while the former have perhaps to do mainly with conduction. There are, even in the young stems, fairly large air spaces between the hyphæ. The outer portion of the stipe consists of a looser weft of septate branching hyphæ which produce large flask-shaped cells, (7–9 $\mu \times$ 22–40 μ) pointing outward and giving to the surface a hairy appearance. The stipe is hollow when old.

The club consists of a very thin wall enclosing a gelatinous interior (*figs. 2, 3*). The subhymenial layer is composed of very fine, septate, closely-woven, much branched hyphæ. On the inside of this layer the hyphæ float out in single branching strands which show abundant clamp-connections (*fig. 1*). The clamp-connections appear to agree with those described by Brefeld (9) in *Coprinus*, rather than with those which Harper (10) observed in *Hypochnus*. For in the latter stages walls are formed at both ends of the clamp cell rather than only at the end from which the clamp-cell originated. In some cases the branch which forms the clamp is of considerable length, forming a large loop (*fig. 5*). It was also observed that in many cases the ends of approaching hyphæ are fused, forming a similar figure to that of a large clamp (*fig. 9, a*). The hymenial layer shows differentiation into three kinds of cells. The "paraphyses" which are probably immature basidia, are small and closely packed (*fig. 4*). Large flask-shaped cells prolonged into blunt spine-like processes project outward. Some of them do not reach the surface of the cap while others project beyond (*figs. 1, 10*). They are of the same shape as the hair-like cells of the stem and seem to serve the usual protective purpose of the cystidia of the lower hymenomycetes. They are probably also special excretory cells as is indicated in the abundance of calcium oxalate crystals excreted and in the sunken position of many. The outer ends of these cells are covered by an irregular cap of crystals (*figs. 6, 8*). A third distinct type of cells in the hymenium are the basidia. They are somewhat thicker than the "paraphyses" and the sterigmata protrude beyond the surface. Peck and also Farlow described for this species two-spored basidia. This material shows, however, that the latter carry from two to four spores. Numerous

examples were noted of basidia bearing either three or four sterigmata. The basidia are barrel-shaped and considerably larger in diameter than the hyphæ from which they arise. The sterigmata are borne at the summit in the usual manner for hymenomycetes. The spores are oval in shape and about $1.6 \times 2.5\ \mu$ in size.

Physalacria inflata apparently enjoys a wide distribution but seems never to occur in great abundance. It has been collected in S. Car. (1), the White Mountains (8), New York (11), and in Minnesota. As far as I know these are the only recorded occurrences.

Systematic Position.

Physalacria has been assigned to the Clavariaceæ. Among the genera of this family *Baumanviella* (P. Hennings) seems to be most nearly related, though this genus contains single-spored basidia. *Glœocephala* (Massee) differs considerably from *Physalacria*, not only in one-spored basidia but also in the localization of the hymenium on the lower surface of the more or less flattened club and in the prominence of its cystidia-like hairs on the upper surface. *Pistillaria* and *Typhula*, on the other hand, approach in form and texture the true *Clavaria* types. In certain aspects *Physalacria* also shows interesting resemblances to the Trembling fungi, *e. g.*, to such forms as *Ditiola* amongst the Dacromycetineæ. In *Physalacria* a somewhat gelatinous region is found below the subhymenium, though this gelatinous region is not extensively developed. The forked basidium of *Ditiola* removes it far from *Physalacria*, yet the partial gelatinization of the club of the latter is one of but a few such instances among the *Clavariaceæ*.

Other Species.

Physalacria langloisii E. & E. (4) is a very small species found in Alabama in 1888. It grows on rotten wood and is less than 1 mm. in height, and is distinguished from *P. inflata* (S) Peck, by the smaller size and urn-shaped cystidia.

P. orinocencis Pat. (5) is also a small species about 3 to 4 mm. high. Found in northern South America. It grows in clusters, has an inflated club which appears (from figures in Nat. Pflanzenfamilian Fungi, 1 [1] **: 131. 1898) to be more or less conical in form and its hymenium covers the whole surface of the club.

P. stillboidea (Cke.) Sacc. (7) was described by Cooke (6) (under *Pistillina stillboidea* Cooke) from New Zealand material on *Panax* leaves. It is also very small, about 3 mm. in height, with hollow, globose, depressed club. Cooke (6) also states that *Pistillina paradoxa* B. & C. (*Crinula paradoxa* B. & C.) must also be referred to the same genus as *Pistillina stilboidea* Cooke. Among others he cites as exsiccatæ Thümen Myc. Univ. No. 208, and Ellis N. A. Fungi No. 23 on living leaves of *Quercus*. These two specimens have been examined and prove to be *Cronartium asclepiadeum quercinium* B. & C. They agree with Ellis and Everhardt N. A. Fungi No. 1881, second series.

The genus *Physalacria* as at present known therefore, comprises four species, two North American, one South American, and one Australian.

FIGURE ON PLATE XLIX.

Figure 16 Photograph of plant, natural size.

DESCRIPTION OF PLATE LIII.

Figures 2 and 3 are magnified 5.5 all the remaining figures ar magnified 455 times.

Figure 1. Detail of section vertical to surface of club.

Figure 2. Diagram of vertical median section through whole plant; *a*, hymenium; *b*, closely packed hyphæ; *c*, interior gelatinous portion; *d*, layer of flask-shaped cells; *e*, interior portion shown in fig. 7; *f*, hollow central portion of old stem.

Figure 3. Same as fig. 2 except that it is taken at right angles to flat surface. Lettering same as fig. 2.

Figure 4. Small portion of hymenium showing basidia with spores and also sterile cells between.

Figure 5. Clamp connections of loose inner hyphae. Stages in formation.

Figure 6. Detail of flask-shaped cells on surface of stipe.

Figure 7. Cross section of inner portion of stipe. *a*, intercellular space; *b*, large cells; *c*, smaller cells.

Figure 8. Cystidial cell of hymenium.

Figure 9. Peculiar hyphal septations; *a*, anastomosing of two approaching hyphal ends.

Figure 10. Cross section of outer portion stipe; *a*, flask-shaped cells; *b*, hyphæ beneath the surface.

Figure 11. Longitudinal section of portion shown in fig. 10.

Figure 12. Detail of large cells in stipe.

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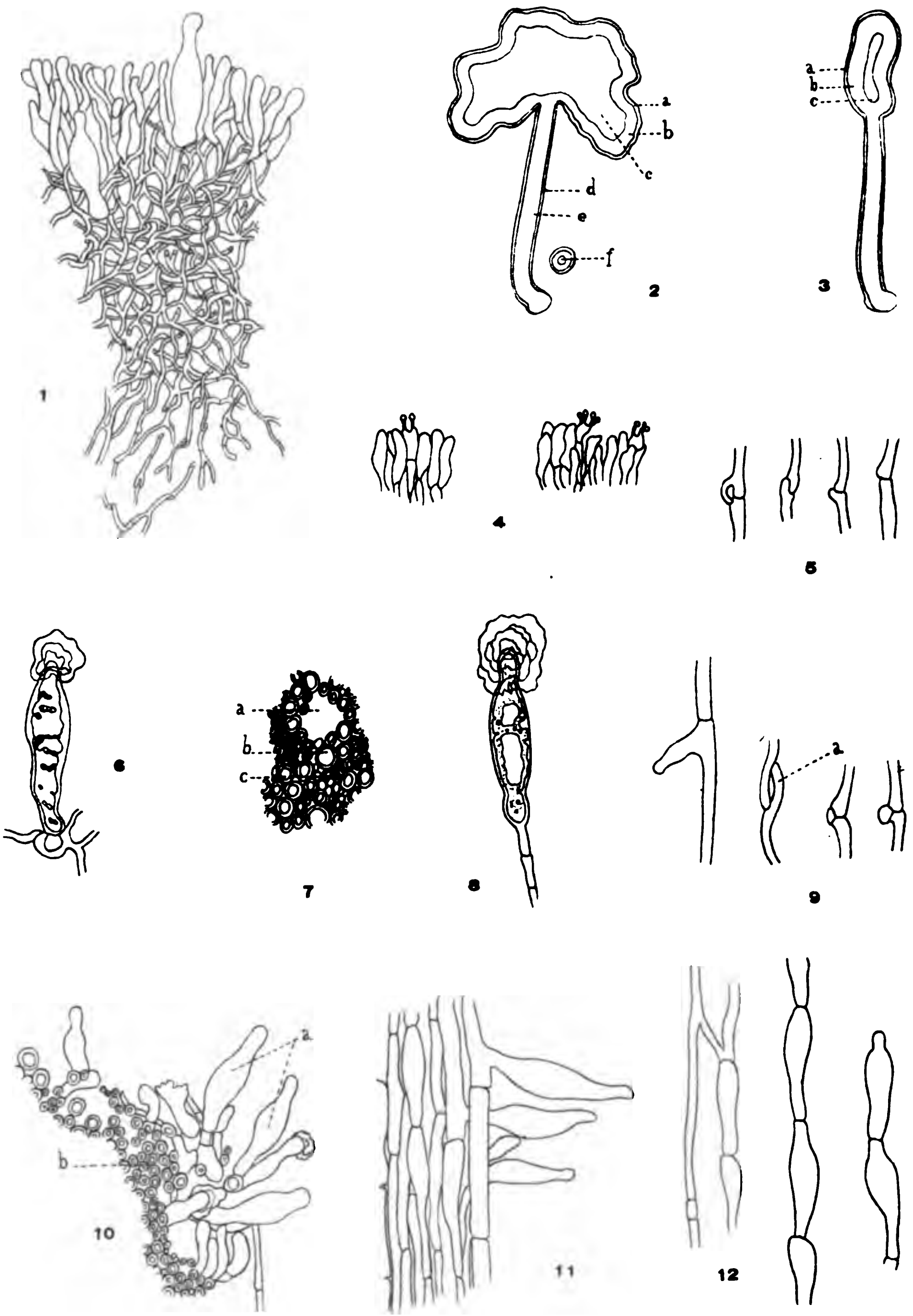

PLATE LIII.

HELIOTYPE CO., BOSTON.

XXIX. SYMBIOSIS IN THE GENUS LOLIUM.

E. M. Freeman.

The existence of fungus hyphæ in *Lolium temulentum*, *L. perenne* and *L. italicum* furnishes interesting relationships between host and parasite. Nothing has as yet been done with the two latter species but the life-cycle of the *Lolium temulentum* fungus is perhaps completely known. There is however no reason for supposing that they differ at all from *L. temulentum* in their life-histories. It cannot be affirmed without reservation that the entire life-history of *L. temulentum* is understood, but it can be affirmed that the yearly life-cycle is known, and that the parasite can live on indefinitely, infecting generation after generation of *Lolium* plants without spore intervention.

The facts of the life-history are briefly as follows: certain grains of *L. temulentum*, varying in number in ordinary commercial mixtures of the grains, from 85 per cent. to 98 per cent. of the total number, show a layer of hyphæ in the hyaline layer just exterior to the aleurone cells. Occasionally these hyphæ penetrate into the endosperm, between the aleurone and starch cells, but never enter them. The fungus does not apparently thrive in the endosperm. On the convex side of the grain the hyphae extend almost or quite to the tip of the scutellum but never enter the scutellum from this point. Along the grain groove the hyphæ are missing except at the very base where an infection patch exists, from which hyphæ can be found penetrating into the base of the scutellum of the embryo and from here to the growing point of the plumule, where a considerable patch of mycelium is developed and remains dormant until the grain germinates. On germination the hyphæ keep pace in their growth with that of the growing point and can be found here throughout the remaining life of the plant. The hyphæ develop in all of the branches and also in the leaf-bases. The appearance in the latter is explained in the similar chemotactic properties of the basal leaf-meristem to those of the stem growing-point. In the young ovaries the hyphæ permeate the nucellus and here develop luxuriantly. They are pushed back by the

elongation of the embryo-sac and at the time of fecundation of the egg the hyphæ along the funicular region have ceased growth, thus causing the isolation of a patch of hyphæ between the point of the attachment of the ovule and the micropyle. This later becomes an infection-layer, for from this patch arise those hyphæ which penetrate the embryo. The hyphæ do not enter the embryo until the latter shows the rudiments of the scutellum and growing point. As soon as the latter is established hyphæ grow from the infection-layer directly to the growing point and by the time the grain is mature have built up a patch of mycelium. Thus the mycelium passes from generation to generation of the host by direct infection and is apparently able to dispense with spore formation.

Since these facts were established I have attempted in various ways, by altering the conditions of growth of the fungus to induce it to form spores but all efforts have as yet failed. The most obviously probable way of succeeding in this attempt seemed to be the following. If the growth of the young embryo were prevented the fungus might establish an extraordinarily vigorous mycelium and in the absence of the embryo might revert to the spore-forming habit, for it would seem probable that the ancestral form might have formed its spores or a sclerotium in the ovary. In one respect expectations were realized, for a vigorous mycelium in the nucellus was produced. In fact the hyphæ were so densely compacted as to constitute a sclerotium-like body; but this was very small. Whether or not the fungus inhibited the production of the normal amount of nucellar tissue was not to be determined, but could now be ascertained since plants with and plants without the fungus can be raised at will. However the fungus refused to form spores. Two explanations might be offered for this failure: (1) the habit of mycelial infection may be so well established that ability to form spores has been lost entirely; (2) the fungus may be some ergot-forming parasite or one which forms spores in some other organ of the host plant. Analogy with other forms however indicate the greater probability of the first proposition.

As the development of some parasitic fungi seems to be favored by weakness in the host plants, *L. temulentum* plants with the fungus were partially starved by retention in dark chambers for certain periods. It was hoped that the consequent etiolation would favor the parasite at the expense of the host.

This experiment also failed and a consideration of the nature of the fungus might lead one to predict this result. Very closely adapted parasites thrive best on healthy plants, so that during the vegetative period conditions favorable to the host would favor the parasite also. Whatever the true nature of the *Lolium* fungus or its ancestors may be, there is no doubt that it is now a very highly specialized parasite. Consequently the weakening of the host did not favor a tendency toward spore formation, in the predominance of parasite over host. These experiments therefore only strengthen the supposition that the spore forming power of the fungus has disappeared entirely.

Further cultural investigations have confirmed the result of previous anatomical research on the life-history of the fungus. Twelve plants of *L. temulentum* with the fungus were planted in pots of three each at the Cambridge Botanical Gardens in Cambridge, Eng., and six were left in the open while six were placed under glass bell jars during the flowering season. This precaution was taken to guard against the possibility of the transferrence of fungus spores with the pollen. It should be mentioned here however that no fungus hyphæ have been found in any part of the stamens except at the base as in other leaves. Twelve plants without the fungus were placed under similar conditions. The entire crops of these plants were sent to me in the fall of the same year. The number of grains received in each case was as follows:

From plants with the fungus in the open	3,596
From plants without the fungus in the open	222
From plants with the fungus covered at flowering	1,071
From plants without the fungus covered at flowering	824

Out of these 100 of each were examined to determine the presence of the fungus. In every case 100 per cent. came true to the parent plant. Of another lot of with-fungus plants 100 grains were examined and again 100 per cent. were found infected. This should establish beyond a reasonable doubt both the accuracy of this method of infection and the existence of two races of *L. temulentum* one with and the other without a fungus and further supports my previous researches on the modus operandi of infection.

It is a very noticeable fact that the crops of these Cambridge plants show a considerable difference in the number of grains produced by the two races and that the plants with the fungus

seem to be the more vigorous of the two. From the seeds of this crop I planted this last summer an approximately equal number of with- and without-fungus grains under conditions as nearly alike as possible. The number of grains obtained was not determined but the experiment was undertaken merely to observe the growing plants.

Both races seem to thrive well but the with-fungus plants were without doubt on the average more vigorous. All observers who have worked with *L. temulentum* agree that the fungus exercises no noticeably injurious effect upon the host. The above comparisons indicate that not only is this true but that we have here experimental evidence of a case of true symbiosis — a symbiosis differing in many respects from mycorrhizal symbiosis and the symbiosis of the lichens. This condition is not so remarkable when we consider the well-known cases of those grass smuts where the presence of the fungus is not betrayed until spore formation. In fact from the analogy of stimulation of many rusts as well as smuts in hypertrofication, etc., stimulation of the *Lolium* plant would almost be expected. The later destructive action in spore formation is here unnecessary on account of the new device for infection. One may therefore consider that this symbiosis has arisen through a previous condition of destructive parasitism.

The nature of the fungus still remains an open question. I have previously enumerated the objections to the assignment of this fungus to the ergot-forming parasites and it certainly has little or no resemblances to the Uredineæ. Nor has it any similarity to the Hyphomycetes and Pyrenomycetes of molded grains. The Ustilagineæ seem to furnish the closest affinities. The growth of the hyphæ in the growing point and the infection of the nucellus are quite similar to certain smuts. The hyphæ seem to be intercellular and in no case was I able to demonstrate the penetration of the cell walls either by the ordinary hyphæ or haustoria. In this respect and in the abundance of septations in the nucellar hyphæ the fungus seems to differ from smuts. In regard to the latter point the fungus seems at this stage to have departed from the normal ustilagine methods and the septations may perhaps be regarded as relics of those septations preceding the chlamydospore formation. It is well known that oat smut infects seedlings. And it would not be unnatural to expect a still earlier infection. But if this were

pushed further forward it must necessarily take place in the intraseminal life of the host. Granting this to be the case, one would expect to find the infection finally taking place as soon as the stem growing point is established, for not until then are the chemotactic substances present to attract the hyphæ. And this is what actually occurs.

An analogous driving forward of the period of infection has probably taken place among those parasites attacking the host plant in the extraseminal seedling stages. It seems not improbable that the oat smut may have formerly been able to infect any immature tissues of the host as the corn smut does. The ovary is a particularly favorable organ both on account of nutrition and distribution facilities and hence, the preference for the ovary as a spore-bearing region for the parasite. The establishment of an attraction by the growing point of the stem and the localization of the sporiferous region in the ovary would naturally be followed by an earlier infection since the presence of the fungus in the unbranched stem multiplies the results of the infection when the stools are mature. The proximity of spores to the grains in sowing becomes obviously advantageous and hence the infection would be pushed forward to the earliest stages of the extraseminal development of the host, as in the oat smut. If now, one presupposes a chemotactic attraction of the growing point for the hyphæ of a smut and also at the same time a failure of the fungus to destroy the endosperm and young embryo during spore formation, then nucellar hyphæ crowded back by the endosperm and embryo, might easily effect direct infection of the growing point of the young embryo. This period would then be shoved forward to the formation of the earliest rudiments of the growing point. It seems probable that the fungus is therefore an ustilagine which has brought forward its infection period to the intraseminal stages of the host and more particularly to the first appearance of the growing point, and has lost the power of spore formation.

Apparently infection of a without-fungus plant of *L. temulentum* is impossible as is also the eliminating of the fungus from the with-fungus plants, barring the possibility of failure to infect all ovaries in an inflorescence, which case seems highly improbable. There exists therefore not only two races of *L. temulentum*, but also of *L. perenne* and of *L. linicola* and probably of other species of *Lolium*, in each case one with, and the other without, the fungus symbiont.

The question now naturally arises whether the symbiosis was established previous to or subsequent upon the origin of these species. In other words has the symbiosis arisen once or three times? The simpler explanation seems at first to be that the symbiosis was previous. This would however presuppose the development in each of the three species of two parallel lines one with and one without the fungus. On the other hand a subsequent establishment of the symbiosis would require like results for the same fungus or for several closely related fungi attacking three species of *Lolium*. A fuller knowledge of the inter-relations between these species as well as of the remaining species of *Lolium* is necessary before an intelligent opinion on this point can be framed.